
GROUND MOVEMENT ASSESSMENT REPORT

23 Downside Crescent
London NW3

Client: Mr & Mrs Callow





Engineer: Conisbee

J13331B

April 2015



Document Control

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CONTENTS

1.0	INTRODUCTION	1
1.1	Proposed Development	1
1.2	Limitations	2
2.0	THE SITE	2
2.1	Site Description	2
3.0	SUMMARY OF GROUND CONDITIONS	3
4.0	CONSTRUCTION SEQUENCE	3
5.0	GROUND MOVEMENTS	4
5.1	Ground Movements - Surrounding the Basement	4
5.2	Movements within the Excavation (Heave)	6
6.0	DAMAGE ASSESSMENT	7
6.1	Damage to Neighbouring Properties	8
6.2	Monitoring of Ground Movements	9
7.0	CONCLUSIONS	9
	APPENDICES	

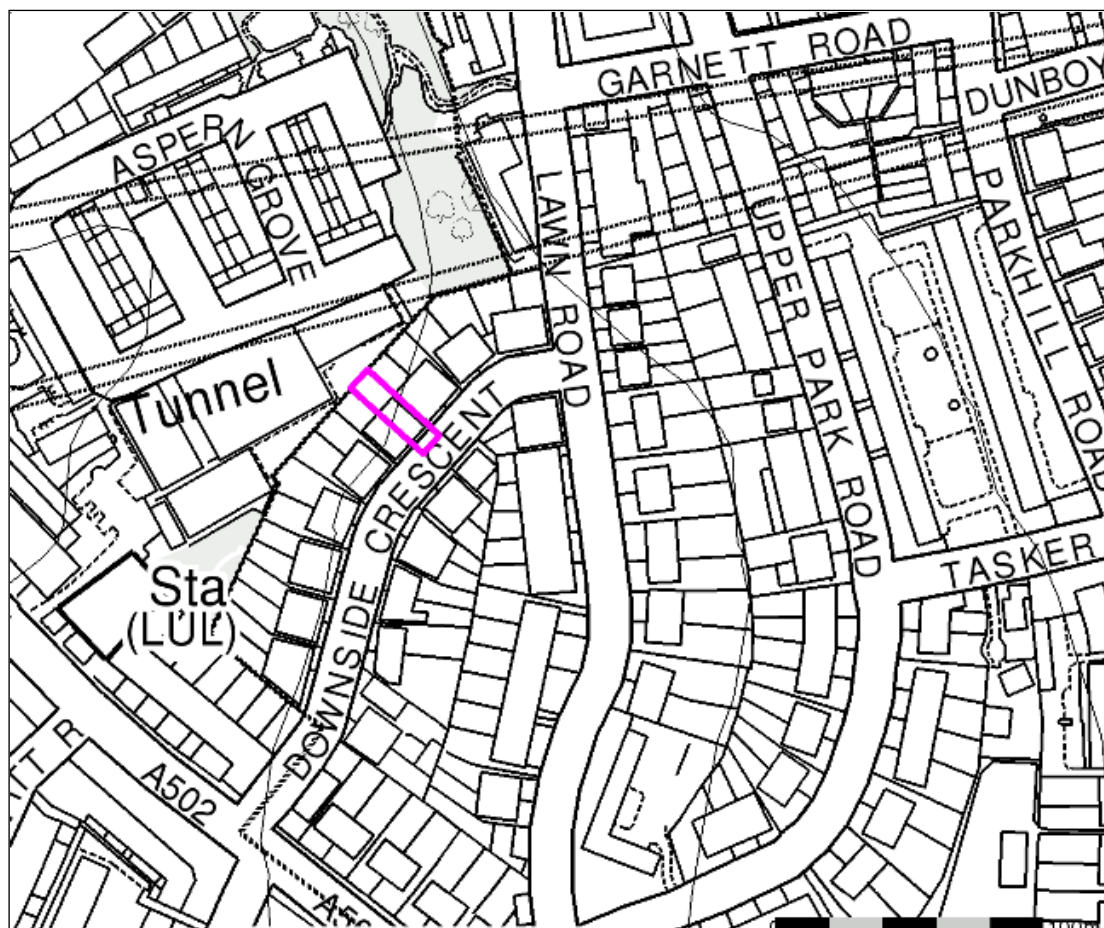
1.2 Limitations

The conclusions and recommendations made in this report are limited to those that can be made on the basis of the investigation. The results of the work should be viewed in the context of the range of data sources consulted, the number of locations where the ground was sampled and the number of soil, gas or groundwater samples tested; no liability can be accepted for information in other data sources or conditions not revealed by the sampling or testing. Any comments made on the basis of information obtained from the client or other third parties are given in good faith on the assumption that the information is accurate; no independent validation of such information has been made by GEA.

2.0 THE SITE

2.1 Site Description

The site is located in the London Borough of Camden, approximately 135 m northeast of Belsize Park Underground Station, 190 m to the south of Royal Free Hospital, and 530 m southeast of Hampstead Heath railway station. The site may be additionally located by National Grid Reference (NGR) 527492, 185174 and is shown on the map below.



The site is reasonably level and forms a roughly rectangular shape with dimensions of approximately 10 m northeast-southwest by 35 m northwest-southeast and is occupied by a mid-terrace three-storey house fronting onto Downside Crescent to the southeast, with a

single storey extension and patio at the rear. The house is bordered by private gardens and houses fronting onto Downside Crescent to the southwest and northeast, and by tennis courts to the northwest. The “Belsize Tunnel” is located 25 m to the north of the site.

The rear garden is laid to lawn with hedges, flower beds and 8 m to 10 m tall semi-mature deciduous trees, and a 22 m tall mature deciduous tree outside the rear of the property. The front garden has a surface covering of gravel with flower beds around the perimeter. The ground floor level and rear garden are approximately 1.00 m above street level and the local topography slopes gently down towards the northeast.

3.0 SUMMARY OF GROUND CONDITIONS

The investigation has confirmed the expected ground conditions in that, beneath a moderate thickness of made ground, London Clay was encountered and proved to the full depth of the investigation, of 6.45 m.

Beneath a 50 mm surface covering of gravel, the made ground comprised dark brown mottled brown sandy silty clay with gravel of flint, brick, charcoal and ash clinker and occasional roots, to depths of between 0.20 m and 0.40 m within the boreholes, and to depths of between 0.56 m to 0.90 m in the trial pits.

The London Clay comprised an initial horizon of soft brown and grey slightly gravelly to gravelly clay to depths of between 1.00 m and 2.00 m. The presence of gravel within the upper layer is consistent with the area being located in an area shown on the BGS map as having a “Head Propensity”.

Below the initial horizon firm becoming stiff, locally fissured, brown mottled grey clay with occasional roots and occasional selenite crystals, was proved to the maximum depth investigated of 6.45 m.

Laboratory plasticity index tests have indicated the clay to generally be high shrinkability with amended plasticity indices between 50% and 61%.

4.0 CONSTRUCTION SEQUENCE

The following sequence of operations has been derived by the consulting engineers to enable analysis of the ground movements around the basement both during and after construction. The sequence of construction is also detailed in drawings (ref 140381-SSK001 and 002-P2 , dated March 2015) and Basement Impact Assessment – Structural Proposals 140381/KH Planning P1, dated March 2015, provided by the consulting engineers.

In general, the sequence of works for basement construction will comprise the following stages.

1. Construct underpinned retaining walls to all boundaries, including underpins beneath the party wall with No 21 Downside Crescent. These are commonly formed in a ‘hit and miss’ sequence using a trench box excavation, commonly sheet lined, shored and strutted; all temporary shoring and propping to be inspected by a suitably qualified person; and

2. excavate new basement and temporarily retain and strengthen, with sufficient propping and walling beams, the new retaining walls.

The underpins will be adequately laterally propped and sufficiently dowelled together, concrete cast and adequately cured prior to excavation of the basement and removal of the formwork and supports.

The detail of the support provided to adjacent walls is beyond the scope of this report at this stage and the structural engineer will be best placed to agree a methodology with the underpinning contractor once appointed.

When the final excavation depths have been reached the permanent works will be formed, which are likely to comprise reinforced concrete walls with a drained cavity lining the inside of the underpinned walls. Reinforced concrete will be used for floor slabs and it is anticipated that heave protection will be installed beneath the basement slab. Following this, the floor slab will be constructed at basement depth and the temporary props will be removed.

5.0 GROUND MOVEMENTS

An assessment of ground movements within and surrounding the excavation has been undertaken using the X-Disp and P-Disp computer programs licensed from the OASYS suite of geotechnical modelling software from Arup. These programs are commonly used within the ground engineering industry and are considered to be appropriate tools for this analysis.

The X-Disp program has been used to predict ground movements likely to arise from the construction of the proposed basement. This includes the settlement of the ground (vertical movement) and the lateral movement of soil behind the proposed retaining walls (horizontal movement).

The analysis of potential ground movements within the excavation, as a result of unloading of the underlying soils, has been carried out using the Oasys P-Disp (Version 19.2 – Build 12) software package and is based on the assumption that the soils behave elastically, which provides a reasonable approximation to soil behaviour at small strains.

For the purpose of these analyses, the corners have been defined by x and y coordinates, with the x-direction parallel with the orientation north-south, whilst the y-direction is parallel with the orientation of east-west. Vertical movement is in the z-direction.

The full outputs of all the analyses can be provided on request and samples of the output movement contour plots are included within the appendix.

5.1 Ground Movements – Surrounding the Basement

5.1.1 Model Used

For the X-Disp analysis, the soil movement relationships used for the embedded retaining walls are the default values within CIRIA report C580¹, which were derived from a number of historic case studies.

The analysis has adopted the ‘installation of a planar diaphragm wall’ to represent the

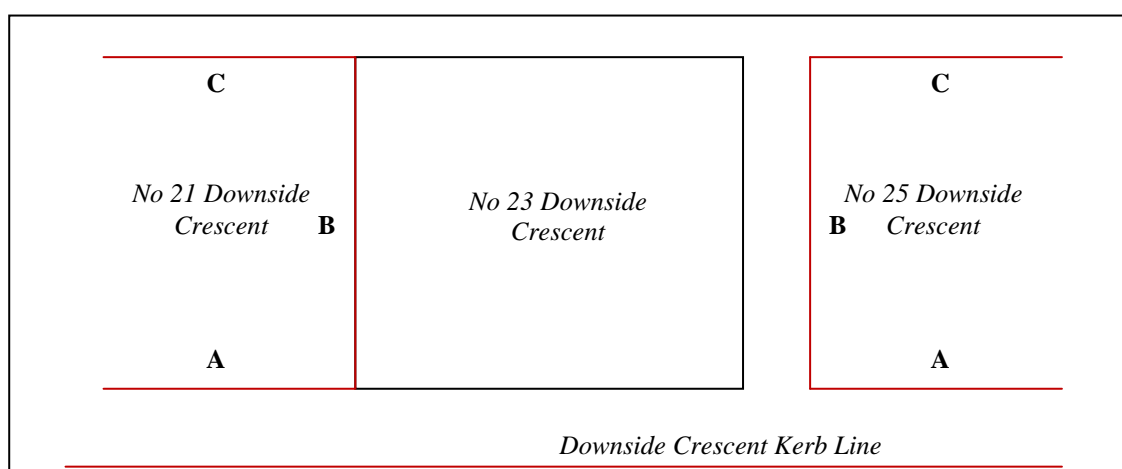
¹ Gaba, A, Simpson, B, Powrie, W and Beadman, D (2003) *Embedded retaining walls – guidance for economic design*. CIRIA Report C580.

installation of underpinned retaining walls on all sides of the excavation. The ground movement curves for ‘excavations in front of high stiffness wall in clay’ have been adopted as being considered most appropriate for the proposed excavation and its support at this site. The new underpinned retaining walls are assumed to be installed to basement level, at a worst case depth of 4.5 m below existing ground level.

5.1.2 Results

The predicted movements are based on the worst case of the individually analysed segments of ‘hogging’ and ‘sagging’ and these are summarised in the tables below. It should be noted that the combined effect of segments acting together typically reduce the resultant movements and the values below are deemed to be conservative.

Displacement Analysis Points:



Wall and Underpinning Installation Phase:

Building Damage Assessment			
Sensitive Structure	Elevation	Vertical Movement	Horizontal Movement
No 21 Downside Crescent	Elevation A	Less than 5 mm settlement	Less than 5 mm
	Elevation B	Less than 5 mm settlement	Less than 5 mm
	Elevation C	Less than 5 mm settlement	Less than 5 mm
No 25 Downside Crescent	Elevation A	Less than 1 mm settlement	Less than 5 mm
	Elevation B	Less than 2 mm settlement	Less than 5 mm
	Elevation C	Less than 1 mm settlement	Less than 5 mm
Downside Crescent	N/A	Less than 1 mm settlement	Less than 1 mm

Excavation Phase:

Building Damage Assessment			
Sensitive Structure	Elevation	Vertical Movement	Horizontal Movement
No 21 Downside Crescent	Elevation A	Less than 10 mm settlement	10 mm to 15 mm
	Elevation B	Less than 10 mm settlement	10 mm to 15 mm

	Elevation C	Less than 10 mm settlement	10 mm to 15 mm
No 25 Downside Crescent	Elevation A	Less than 5 mm settlement	Less than 10 mm
	Elevation B	Less than 10 mm settlement	Less than 10 mm
	Elevation C	Less than 5 mm settlement	Less than 10 mm
Downside Crescent	N/A	Less than 5 mm settlement	Less than 10 mm

The analysis has indicated that the maximum vertical and horizontal settlements that will result from new retaining wall construction are less than 15 mm.

There is a wealth of experience with respect to the construction of underpinned retaining walls, that suggests that ground movements should remain typically within the range of 2 mm to 5 mm following completion of the works and provided that they are installed by a reputable and experienced contractor in accordance with the guidelines published by the Association of Specialist Underpinning Contractors², which indicates that the predicted movements represent a conservative assessment of the likely movements.

5.2 Movements within the Excavation (Heave)

5.2.1 Model Used

At this site unloading of the London Clay will take place as a result of the proposed excavation and the reduction in vertical stress will lead to heave movement. Undrained soil parameters have been used to estimate the potential short term movements, which include the “immediate” or elastic movements as a result of the basement excavation. Drained parameters have been used to provide an estimate of the total long-term movement.

The elastic analysis requires values of soil stiffness at various levels to calculate displacements. Values of stiffness for the soils at this site are readily available from published data and published data³ indicates undrained stiffness values (E_u) of $750 \times C_u$ for the London Clay and a ratio of E' to E_u of 0.75n.

The soil profile assumed in the analysis is based on SPTs from Borehole No 2, along with the SPT and cohesion results from a 20 m deep cable percussion borehole carried out at No 61 Parliament Hill, approximately 750 m to the north.

The proposed excavation will result in a net unloading of 90 kN/m^2 . Following construction of the new basement, a net imposed stress of 150 kN/m^2 will be applied at basement level by the new underpins, with a maximum width at this depth of 1.55 m.

A rigid boundary for the analysis has been set within the London Clay at a depth of about 69 m below existing ground level, where nearby BGS records indicate that the base of this formation is likely to be present. Below this depth the essentially incompressible soils of the Lambeth Group should be present.

5.2.2 Results

The P-Disp analysis indicates that, by the time the basement construction is complete, 5 mm to 10 mm of heave is likely to have taken place at the centre of the proposed excavation, reducing to approximately less than 5 mm at the edges.

² Haslam S, O'Connor L (2013) *Guidelines on safe and efficient basement construction directly below or near to existing structures* ASUC

³ Burland JB, Standing, JR, and Jardine, FM (2001) Building response to tunnelling, case studies from construction of the Jubilee Line Extension.. CIRIA Special Publication 200

In the long term, following completion of the basement construction, a further 10 mm to 15 mm of heave is estimated as a result of long term swelling of the underlying London Clay.

The results of the P-Disp analysis also indicate the likely impact of the proposed basement construction beyond the site boundaries. On the basis of the analysis, total vertical movements outside the proposed basement are unlikely to exceed between 5 mm heave and 5 mm settlement at a distance of approximately 5 m, reducing to negligible movements in excess of 10 m away.

The potential movements for the associated structures are summarised in the table below.

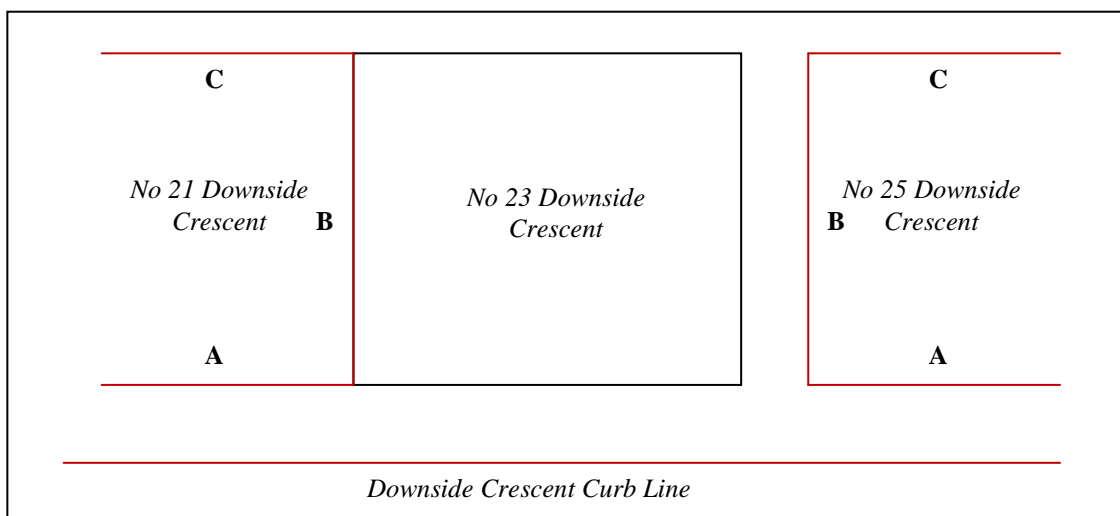
Location	Depth below Ground Level of Analysis (m)	Movement (mm)		
		Short-term Heave (Excavation Phase)	Long-term Heave (Post Construction)	Total Heave
No 21: Elevation A	0.85	Less than 1 mm	≈ 1 mm	< 1 mm heave < 1 mm settlement
No 21: Elevation B	0.85	Less than 5 mm	≈ 5 mm	< 2 mm heave < 1 mm settlement
No 21: Elevation C	0.85	Less than 1 mm	≈ 1 mm	< 1 mm heave < 1 mm settlement
No 25: Elevation A	0.85	Less than 1 mm	Negligible	Less than 1 mm
No 25: Elevation B	0.85	Less than 2 mm	Negligible	Less than 2 mm
No 25: Elevation C	0.85	Less than 1 mm	Negligible	Less than 1 mm
Downside Crescent Road	0.00	Less than 1 mm	Negligible	Less than 1 mm

Alternatively, or in any case, a void or layer of compressible material should be incorporated into the design to accommodate these potential long term movements. If a compressible material is used beneath the slab, it will need to be designed to be able to resist the potential uplift forces generated by the ground movements. In this respect potential heave pressures are typically taken to equate to around 30 % to 50 % of the total unloading pressure.

6.0 DAMAGE ASSESSMENT

In addition to the above assessment of the likely movements that will result from the proposed development, neighbouring structures, Nos 21 and 25, as well as Downside Crescent road are considered to be sensitive structures, requiring Building Damage Assessments, on the basis of the classification given in Table 2.5 of C580¹.

All structures are shown on the plan below.



For the analyses it has been assumed that Nos 21 and 25 Downside Crescent do not have existing basements and the foundation depths are assumed to extend to the same depth as No 23 Downside Crescent, approximately 0.85 m below ground level. Nos 21 and 25 Downside Crescent are assumed to be 10.5 m in height and 10 m in width. No 21 Downside Crescent is known to share a party wall with No 23, whilst there is a gap of 1.8 m between Nos 23 and 25 Downside Crescent.

6.1 Damage to Neighbouring Structures

The combined movements resulting from both retaining wall installation and basement excavation calculated using the X-Disp modelling software have been used to carry out an assessment of the likely damage to adjacent properties and the results are summarised in the table below.

The potential heave movements predicted by P-Disp have not been included in this assessment, which can therefore be considered as conservative, as these movements are likely to have a mitigating effect on the downward settlement predicted by X-Disp.

Building Damage Assessment		
Sensitive Structure	Elevation	Category of Damage*
No 21 Downside Crescent	Elevation A	Category 2 (Slight)
	Elevation B	Category 0 (Negligible)
	Elevation C	Category 2 (Slight)
No 25 Downside Crescent	Elevation A	Category 2 (Slight)
	Elevation B	Category 0 (Negligible)
	Elevation C	Category 2 (Slight)
Downside Crescent	N/A	Category 0 (Negligible)

**From Table 2.5 of C580¹: Classification of visible damage to walls.*

The building damage reports for sensitive structures highlighted in the above table predict that the damage to the adjoining and nearby structures would generally be Category 0 (negligible) to Category 2 (Slight) which fall within tolerable limits.

6.2 Monitoring of Ground Movements

The predictions of ground movement based on the ground movement analysis should be checked by monitoring of adjacent properties and structures. The structures to be monitored during the construction stages should include Nos 21 and 25 Downside Crescent. Condition surveys of the above existing structures will be carried out before and after the proposed works.

The precise monitoring strategy will be developed at a later stage and it will be subject to discussions and agreements with the owners of the adjacent properties and structures. Contingency measures will be implemented if movements of the adjacent structures exceed predefined trigger levels. Both contingency measures and trigger levels will need to be developed within a future monitoring specification for the works.

7.0 CONCLUSIONS

The analysis has concluded that the predicted damage to the neighbouring properties would be 'Negligible' to 'Slight'. On this basis, the damage that would inevitably occur as a result of such an excavation would fall within the acceptable limits.

The separate phases of work, including formation of the underpins and excavation of the proposed single level basement, will in practice be separated by a number of weeks during which time construction of permanent supports, basement slab and underpin curing will take place. This will provide an opportunity for the ground movements during and immediately after underpin construction to be measured and the data acquired can be fed back into the design and compared with the predicted values. Such a comparison will allow the ground model to be reviewed and the predicted wall movements to be reassessed prior to the main excavation taking place so that propping arrangements can be adjusted if required.

APPENDIX

SOIL DISPLACEMENT MODEL RESULTS

HEAVE ANALYSIS RESULTS

SITE PLAN

P-DISP ANALYSIS

Short Term Movement

Total Movement

X-DISP ANALYSIS

Wall Installation

Contour Plots of Vertical Movements and Horizontal Movements

Pile Installation and Basement Excavation

Contour Plots of Combined Vertical Movements and Horizontal Movements

BUILDING DAMAGE ASSESSMENT (X-DISP)

Tabular Output of Results

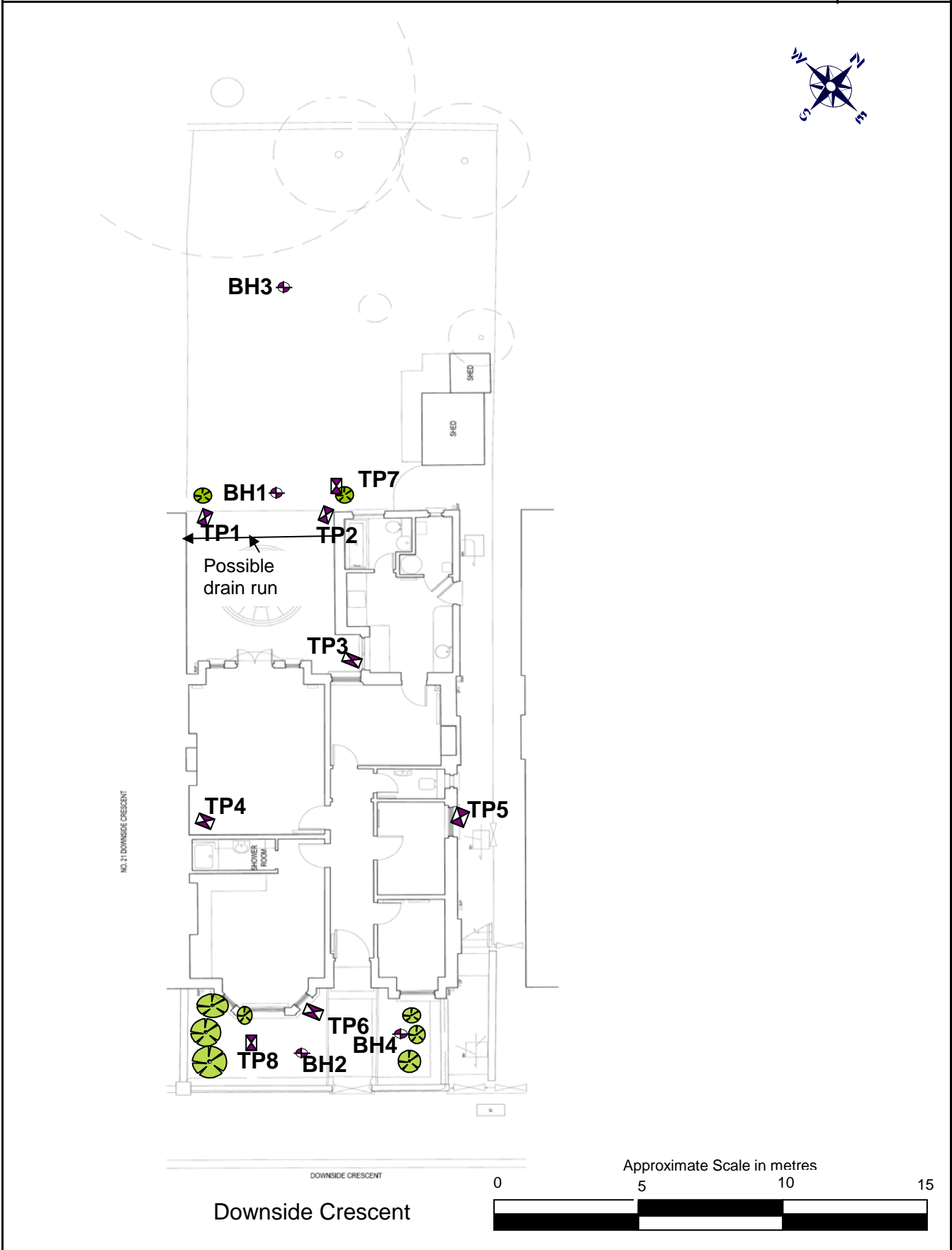
Site 23 Downside Crescent, London, NW3 2AN

Client Robert Callow

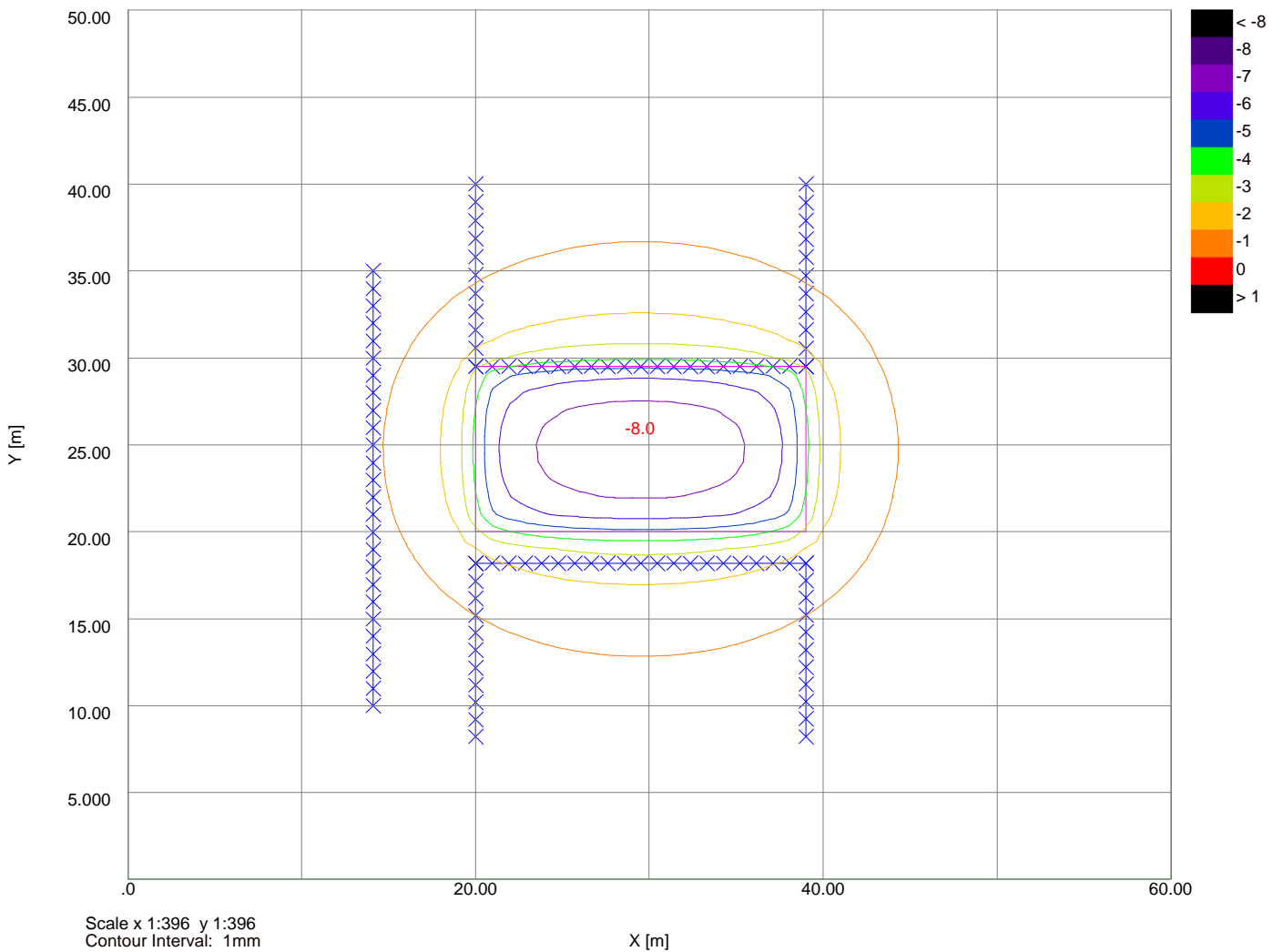
Engineer Conisbee

Job Number
J13331

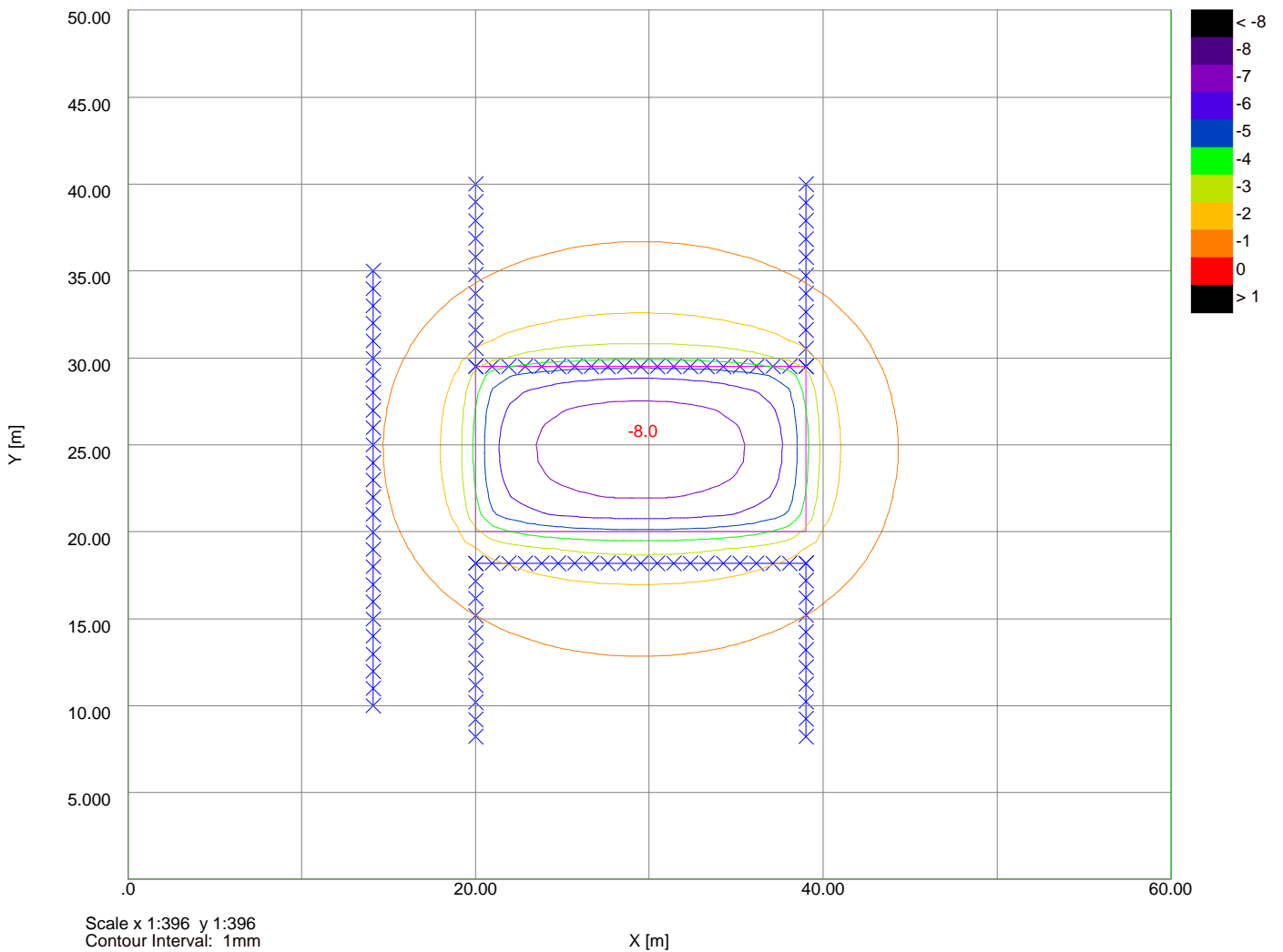
Sheet
1 / 1



Settlement Contours : Grid 1 at 0.0m



Settlement Contours : Grid 2 at -4.500m



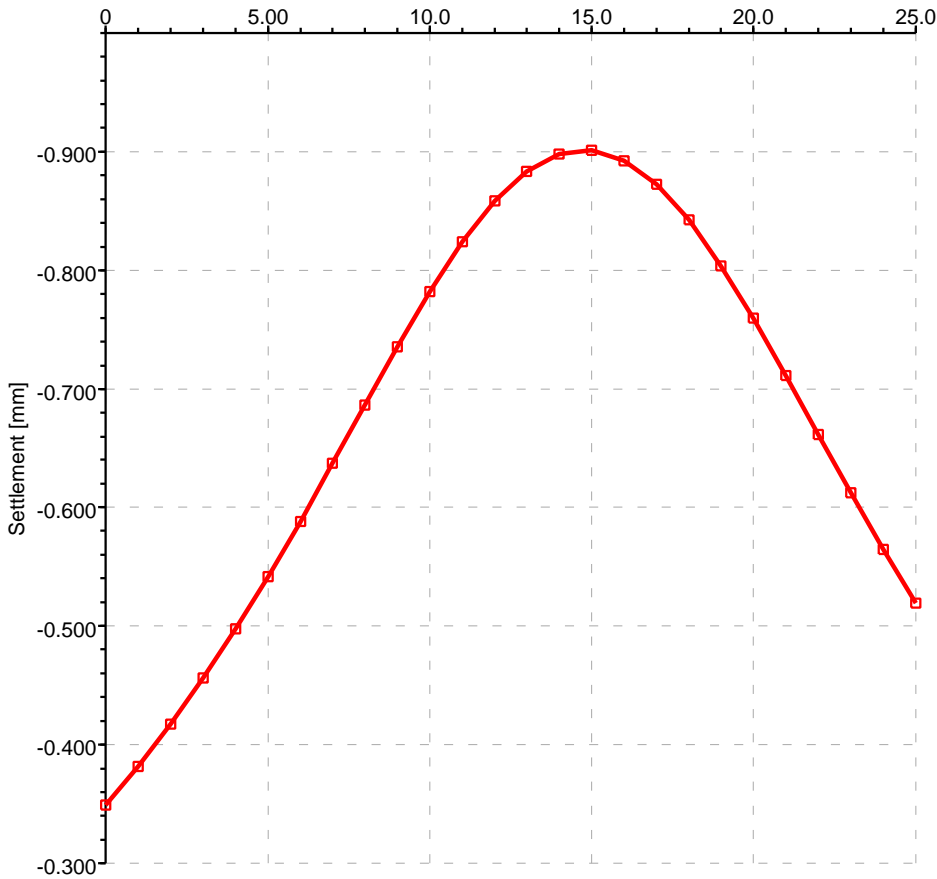
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Contour Interval: 1mm

X [m]

Displacement for DSC

—□— Line Displacement

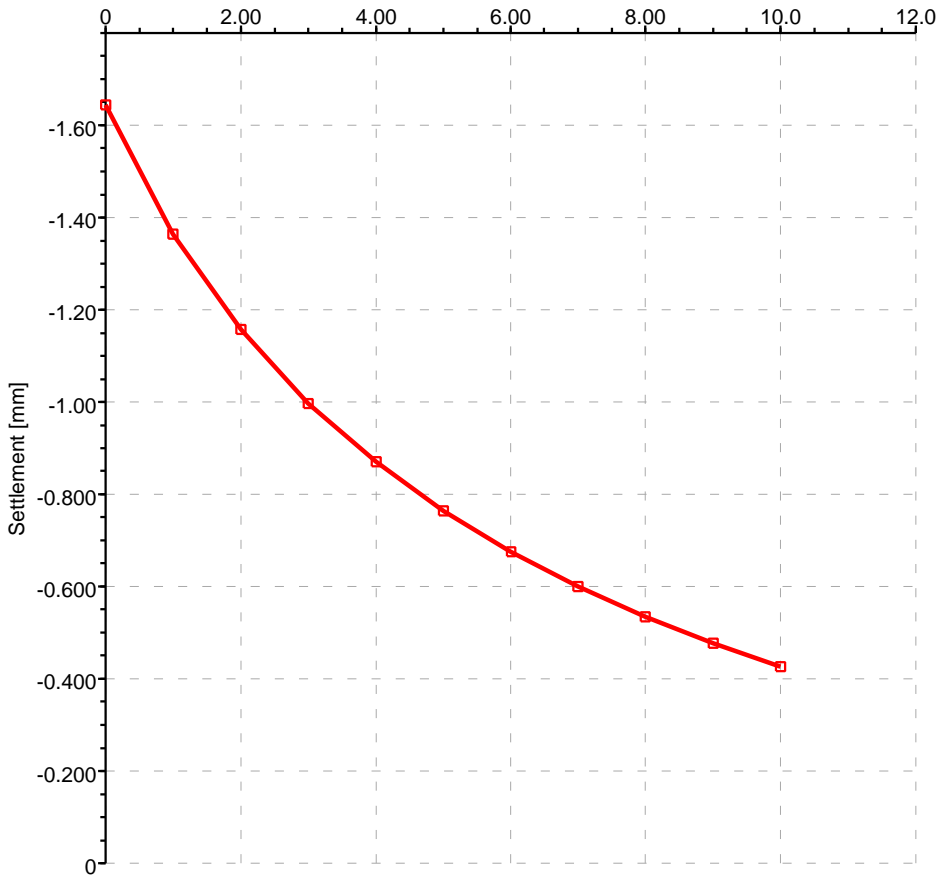
Distance from (14.1,10) in m



Displacement for No25C

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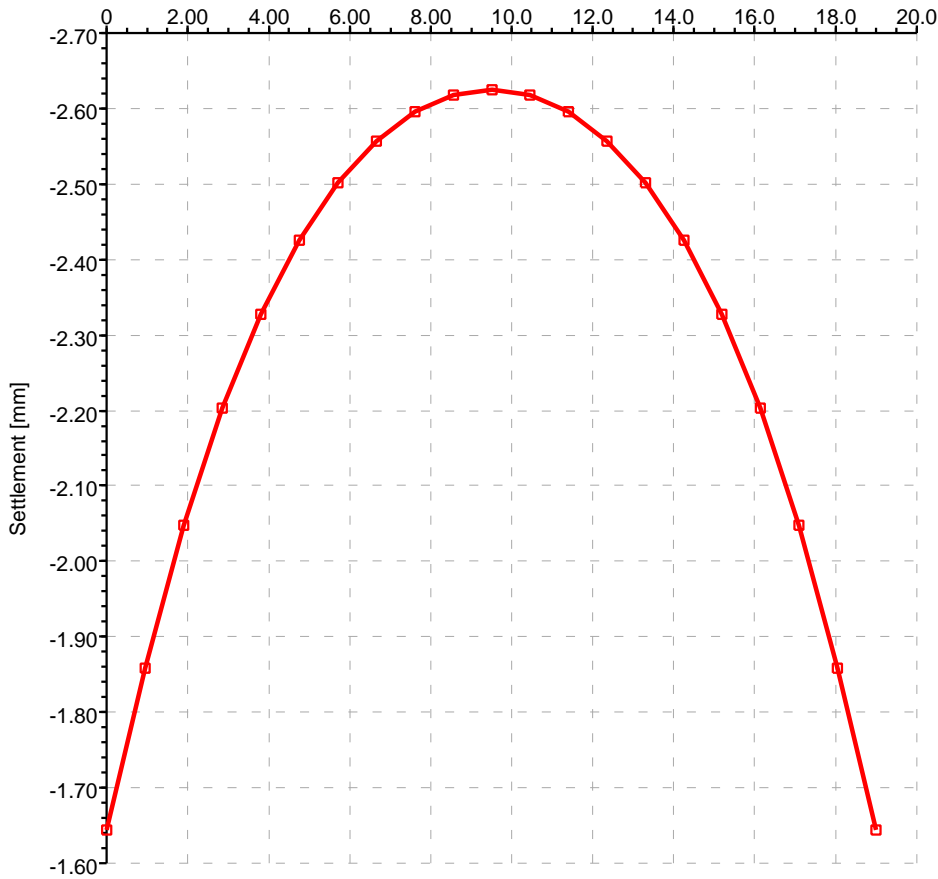
Distance from (39,18.2) in m



Displacement for No25B

Distance from (20,18.2) in m

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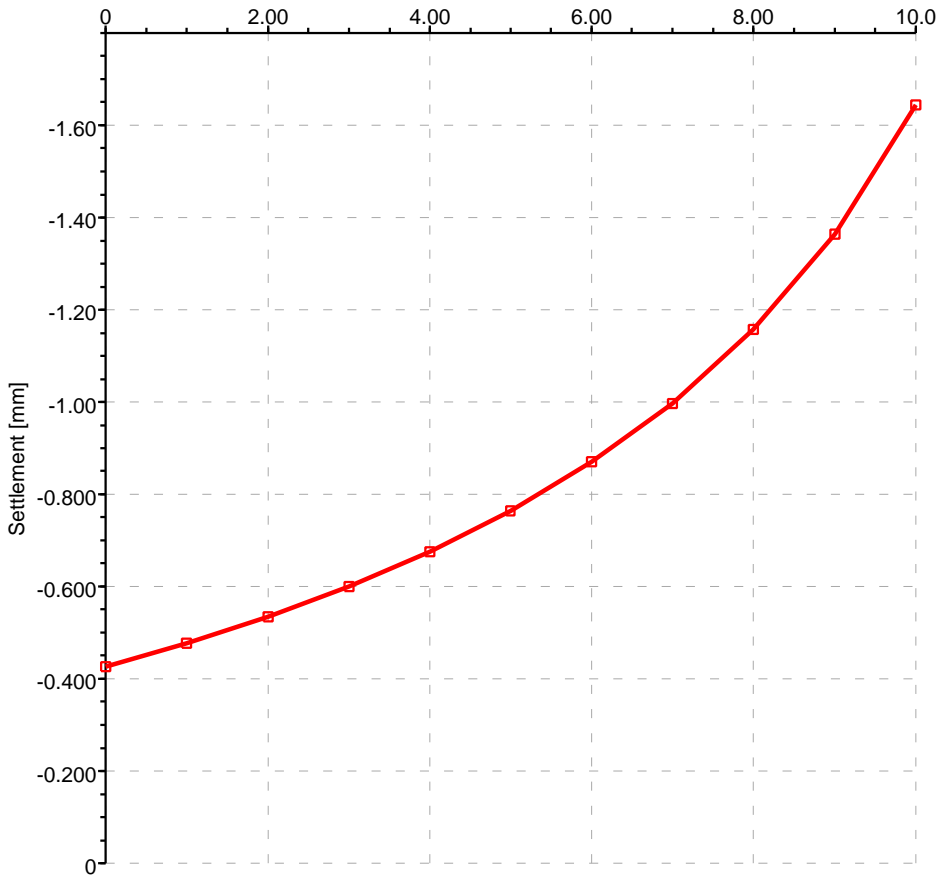


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	07-Apr-2015	

Displacement for No25A

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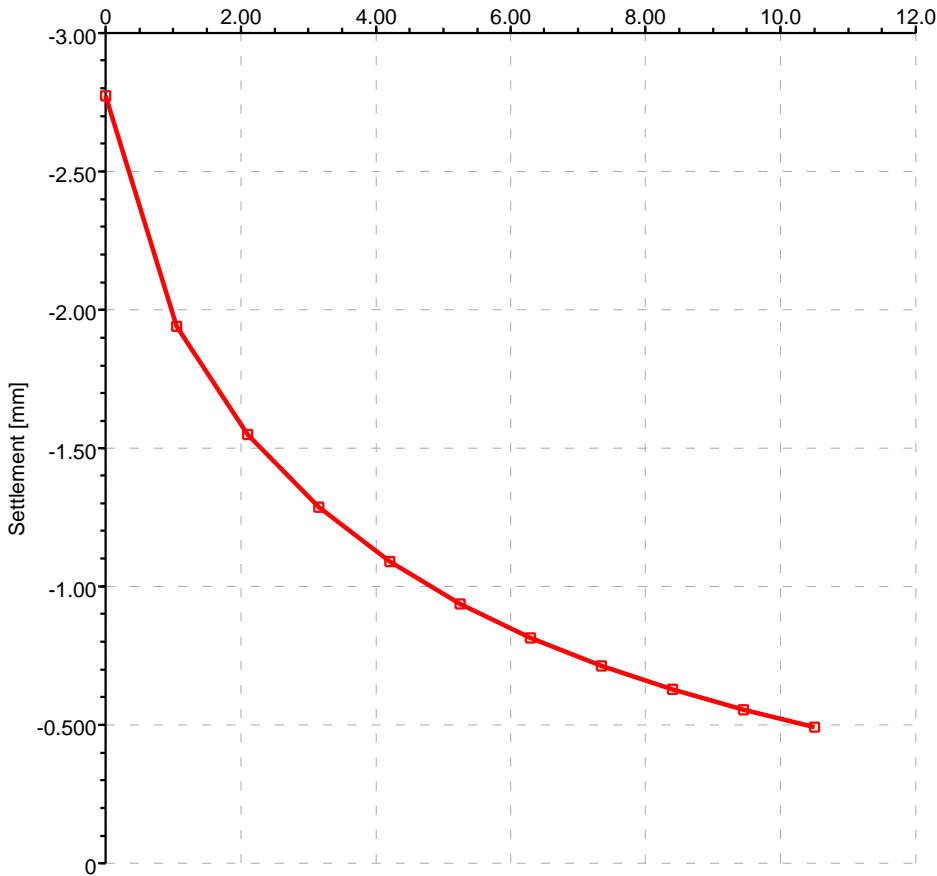
Distance from (20,8.2) in m



Displacement for No21C

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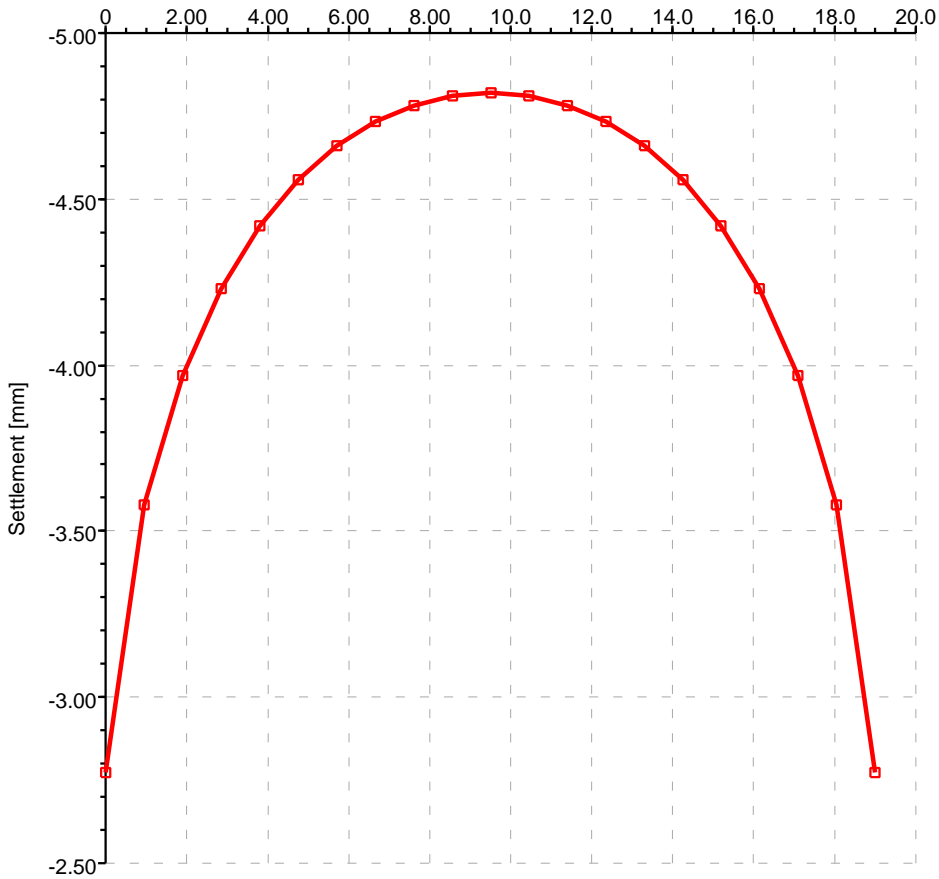
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Displacement for No21B

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Distance from (20,29.5) in m

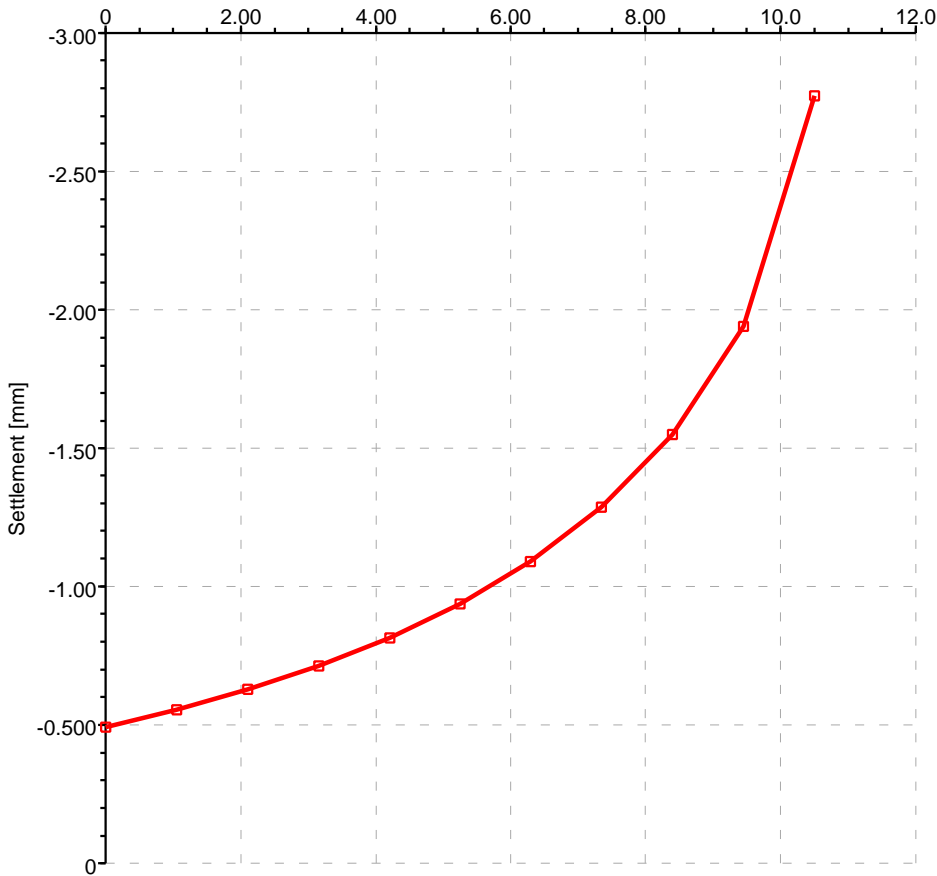


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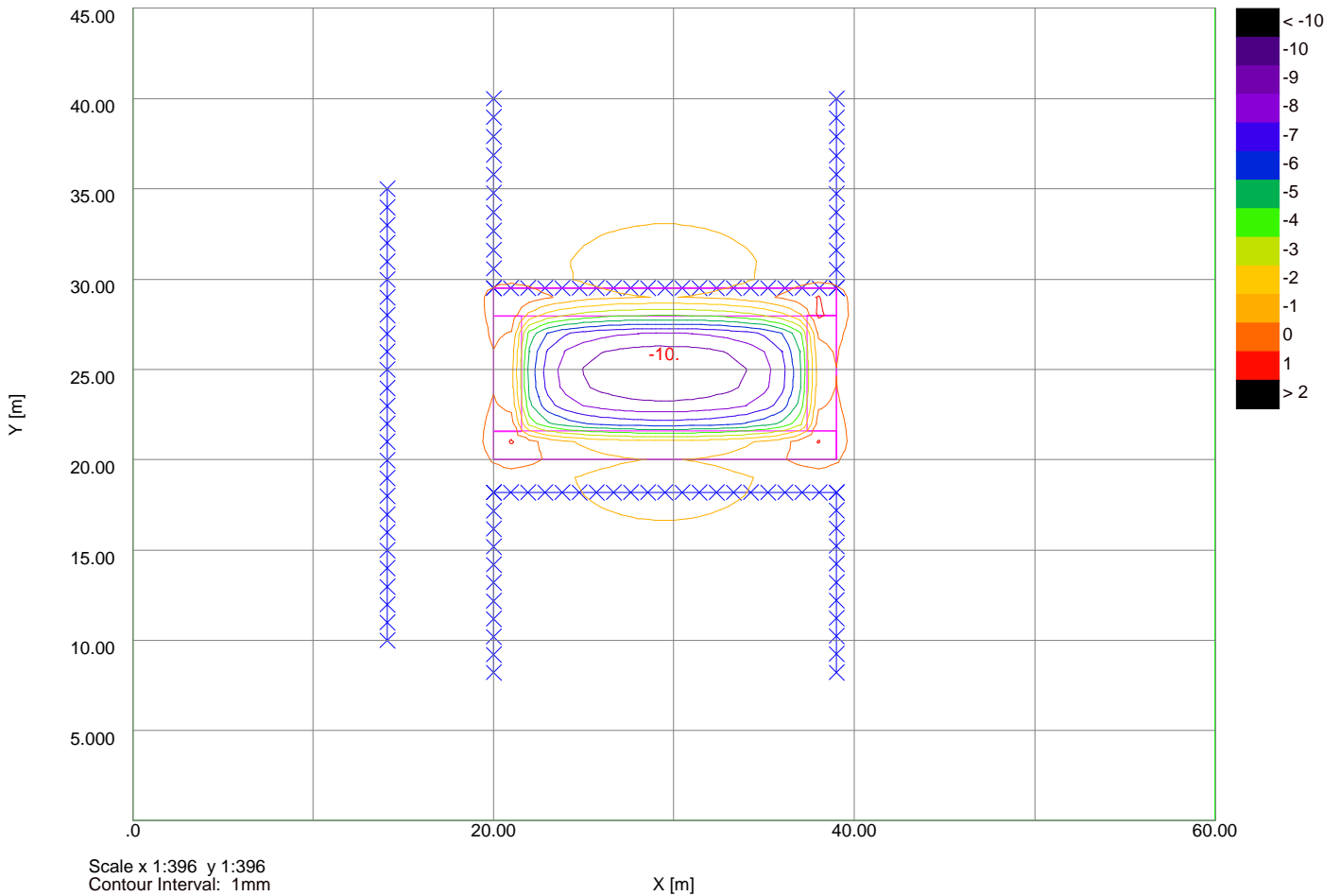
Displacement for No21A

—■— Line Displacement

Distance from (20,40) in m



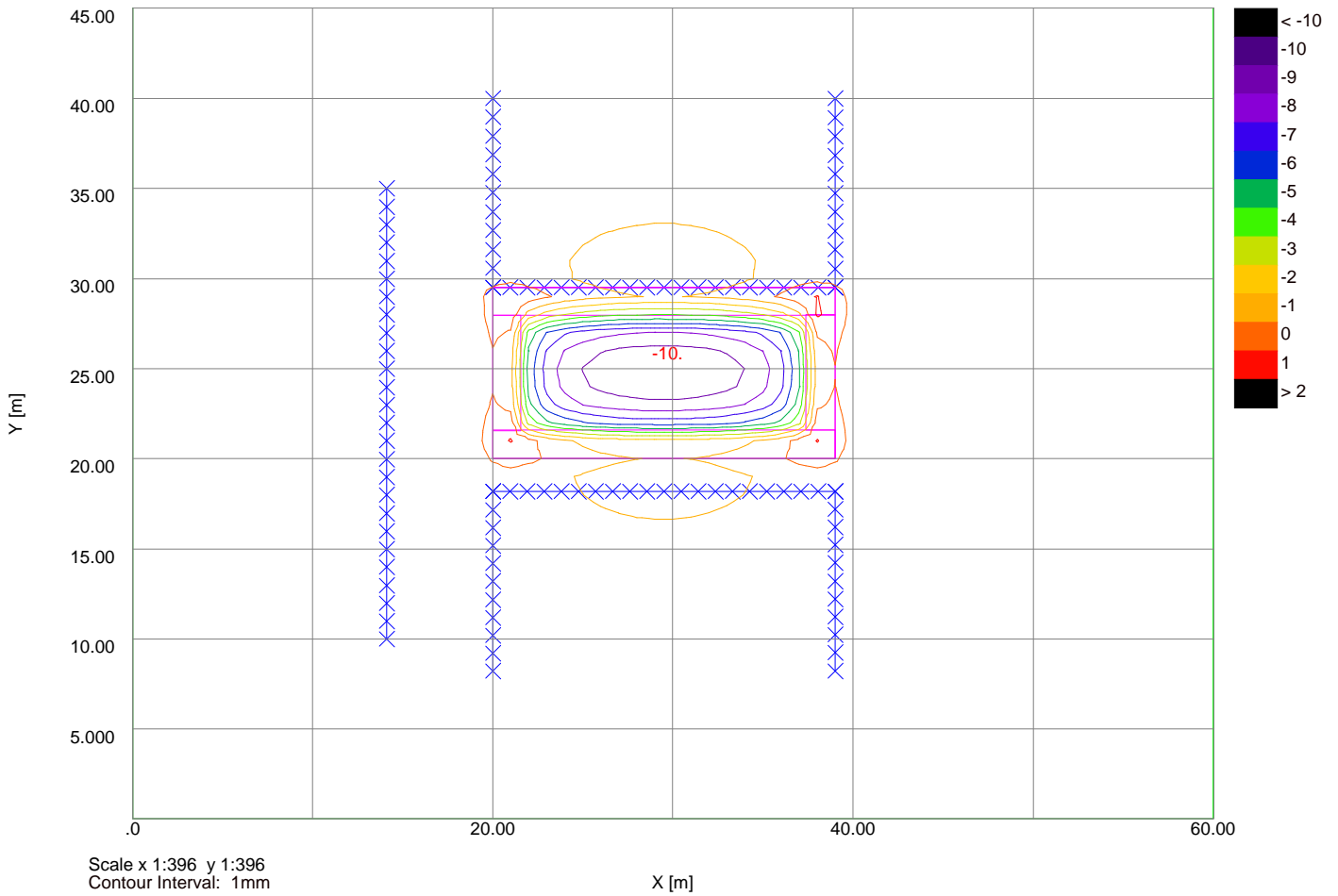
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Scale x 1:396 y 1:396
Contour Interval: 1mm

X [m]

Settlement Contours : Grid 2 at -4.500m

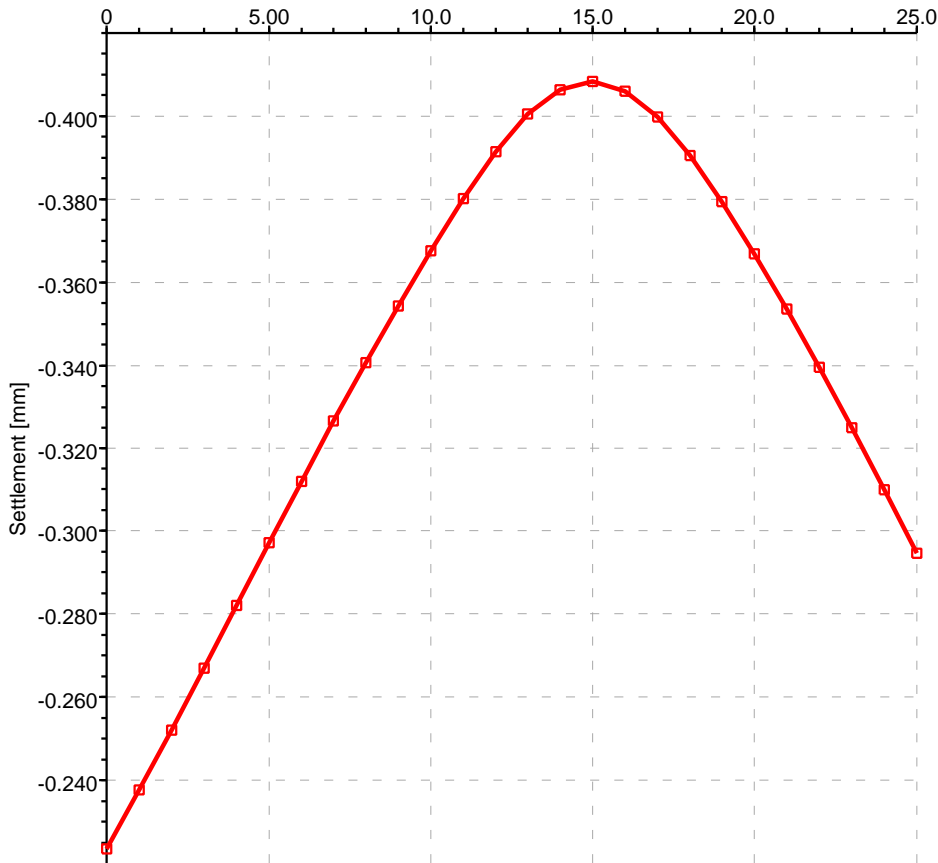


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Displacement for DSC

—□— Line Displacement

Distance from (14.1,10) in m

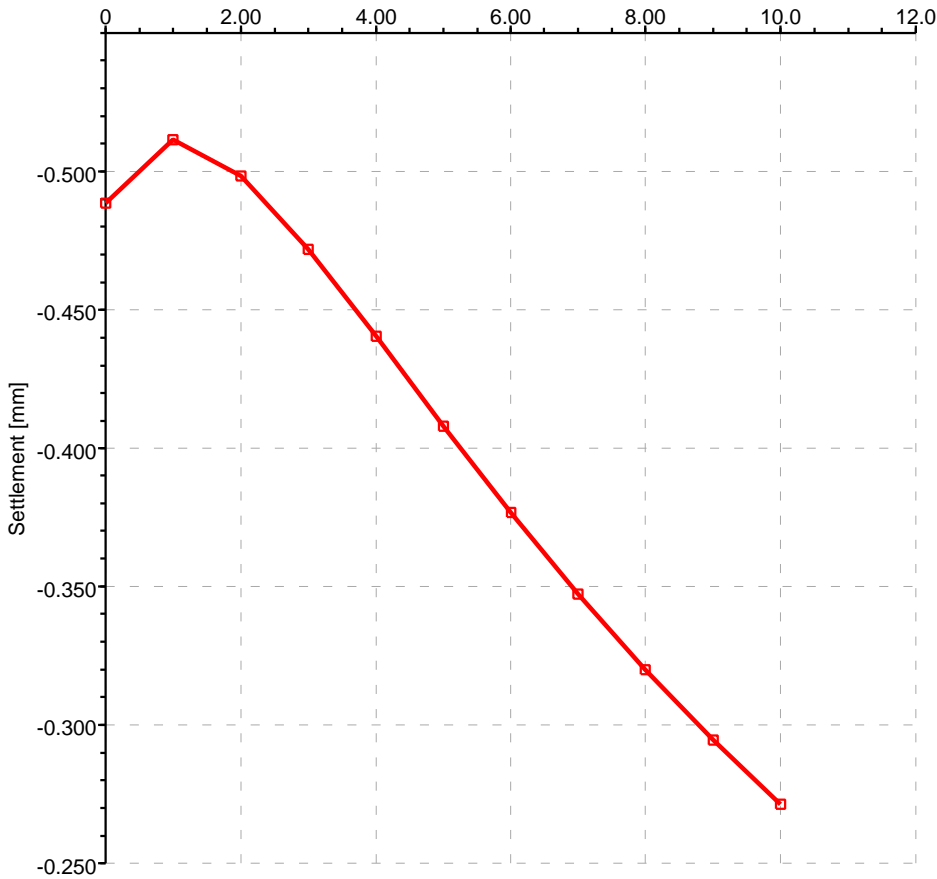


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	07-Apr-2015	

Displacement for No25C

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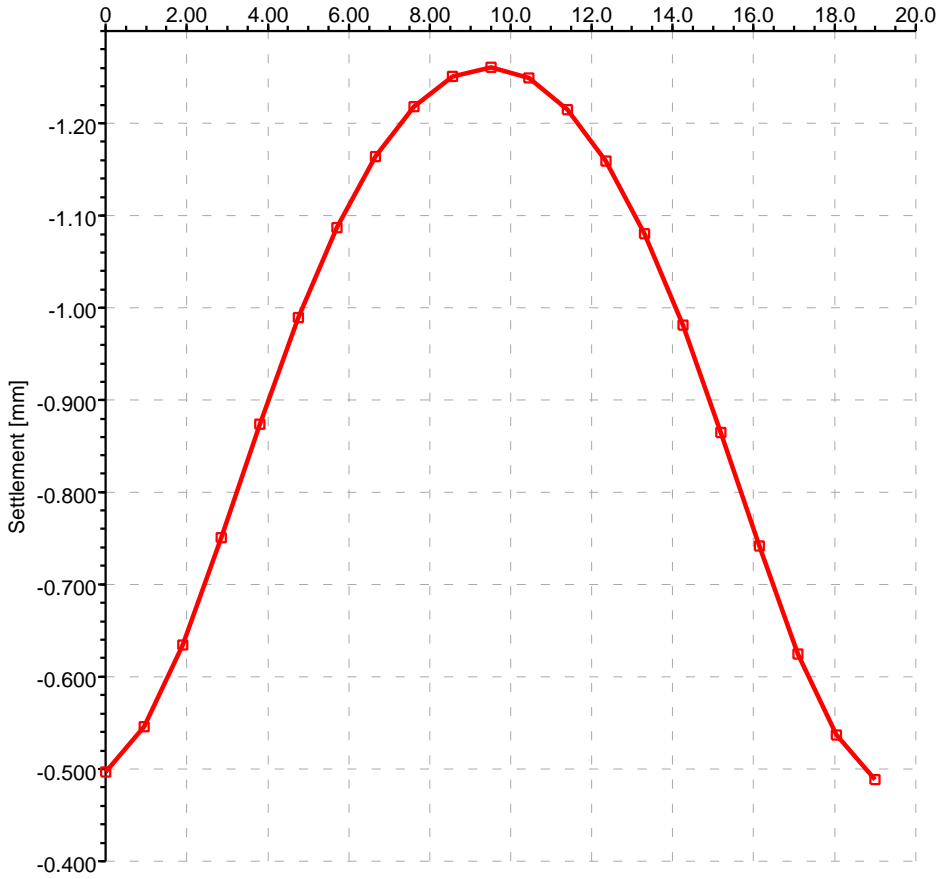


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Displacement for No25B

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Distance from (20,18.2) in m

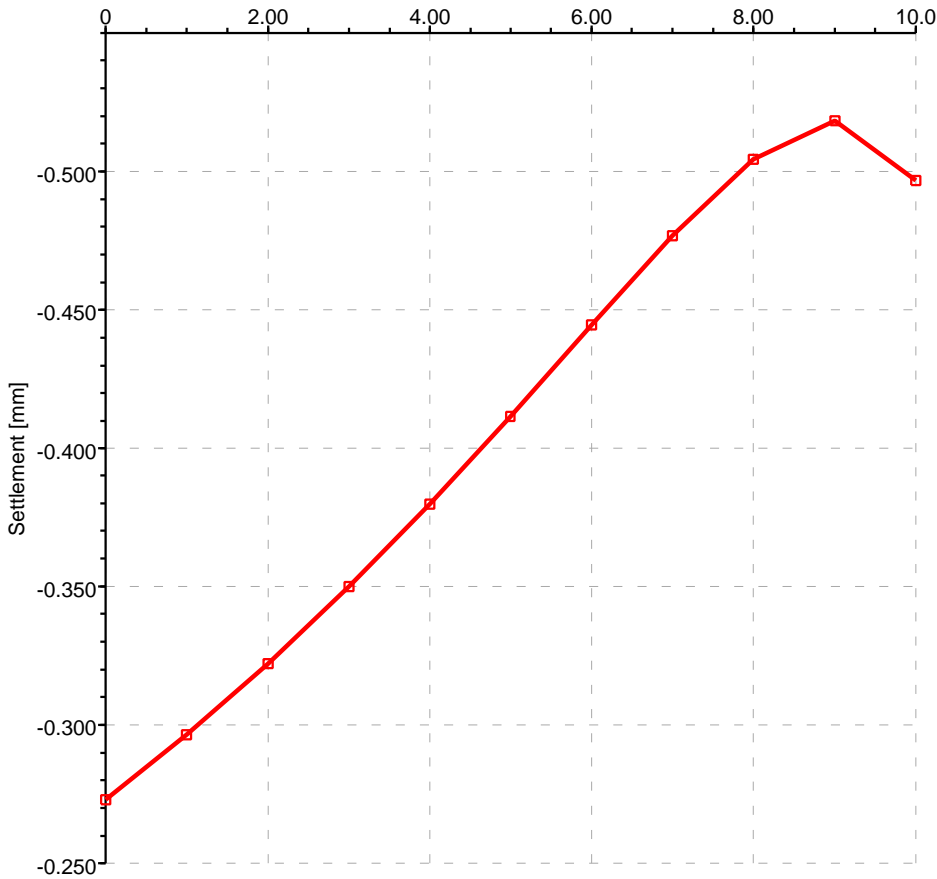


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	07-Apr-2015	

Displacement for No25A

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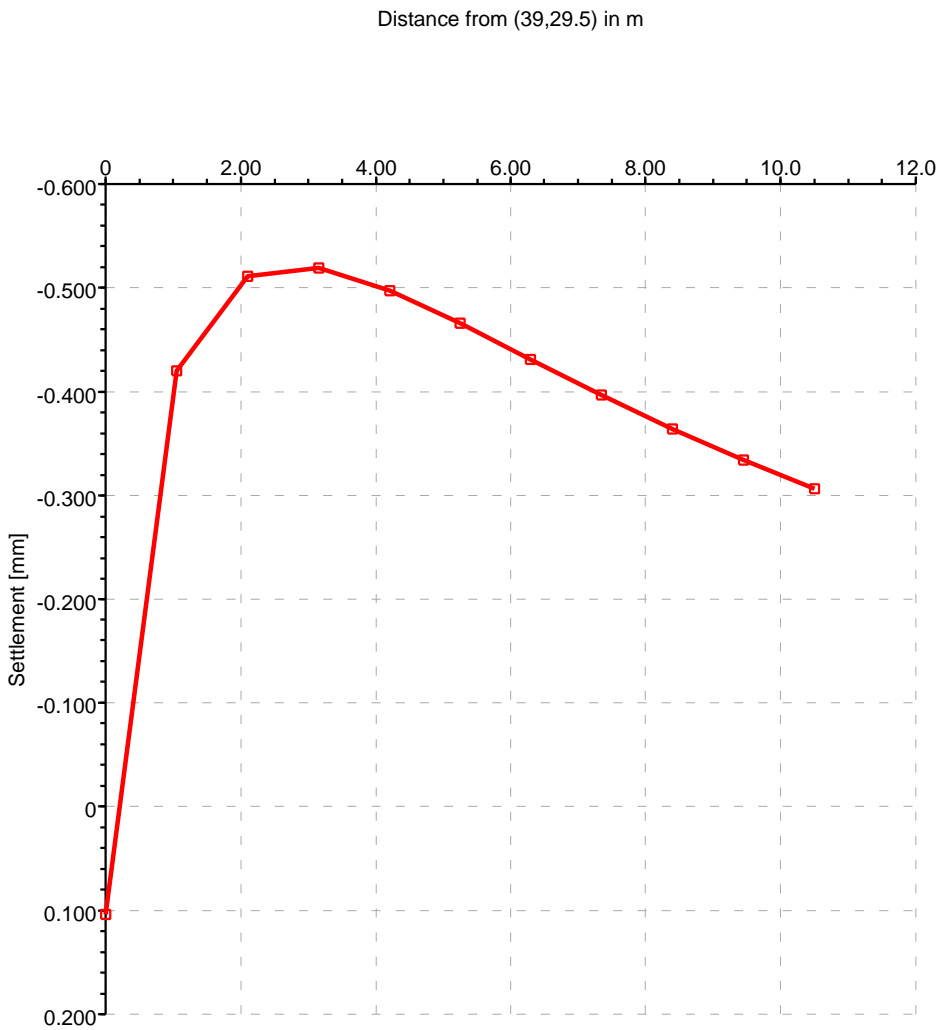
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Drg. Ref.		
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	07-Apr-2015	

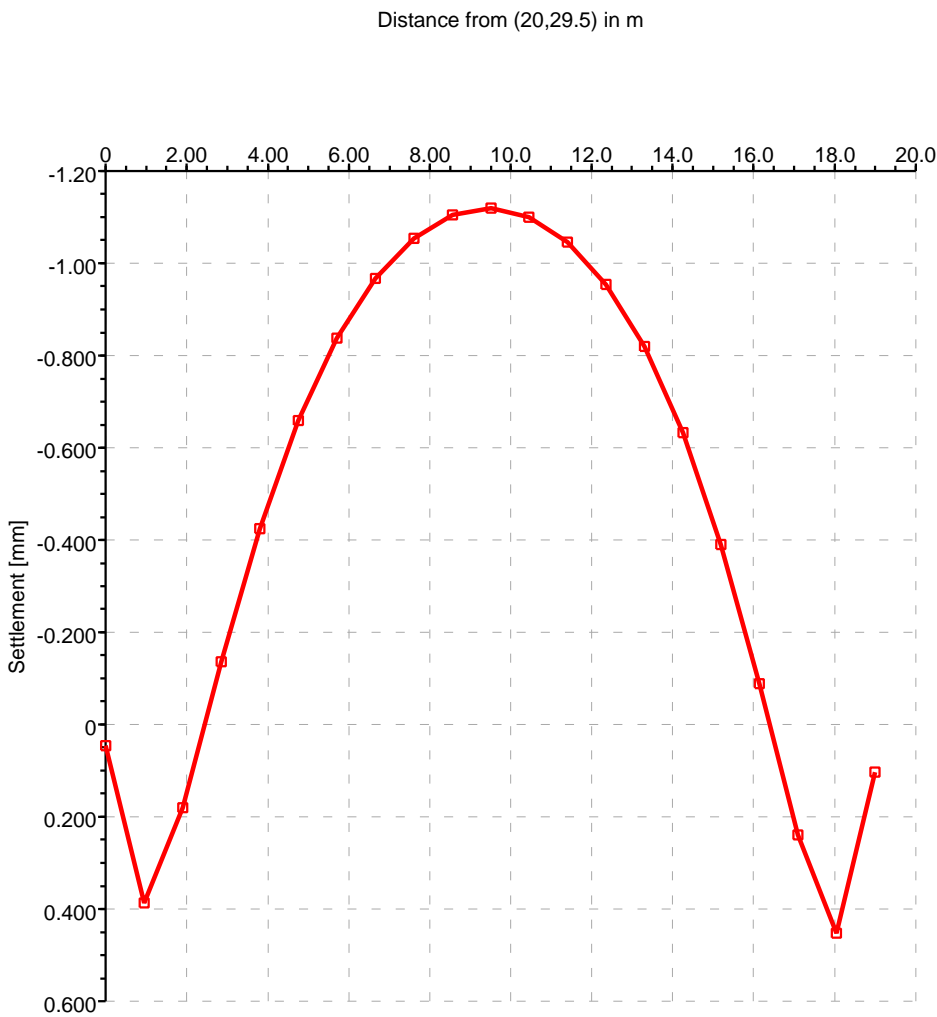
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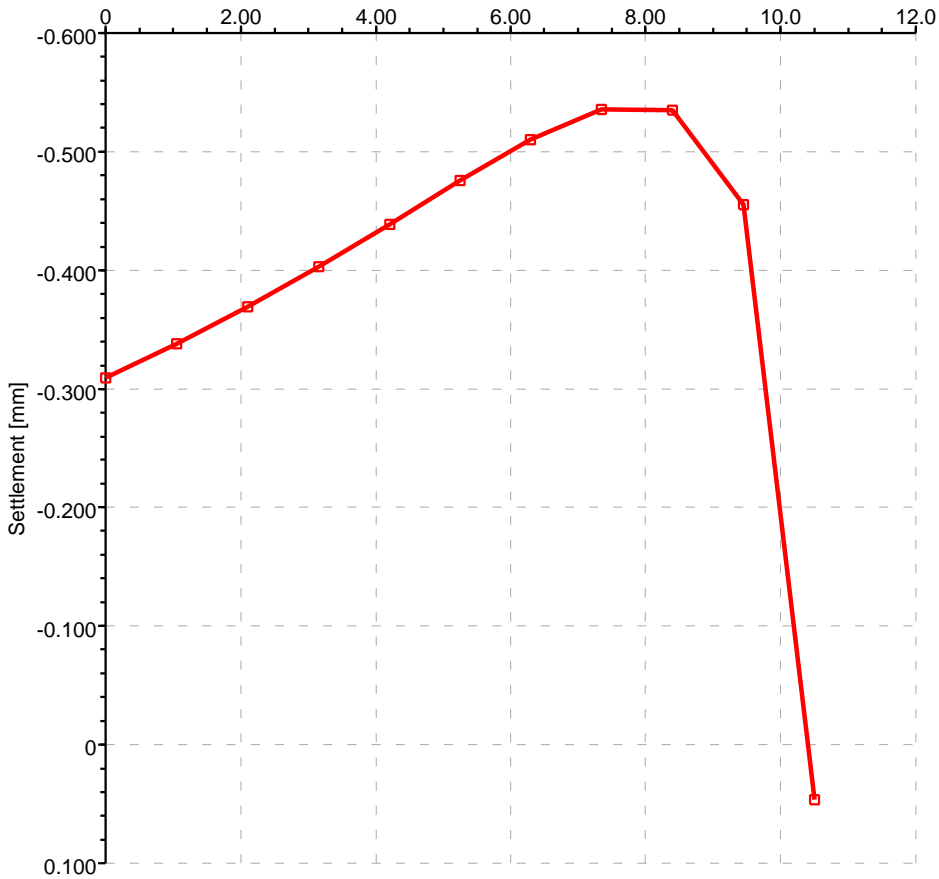
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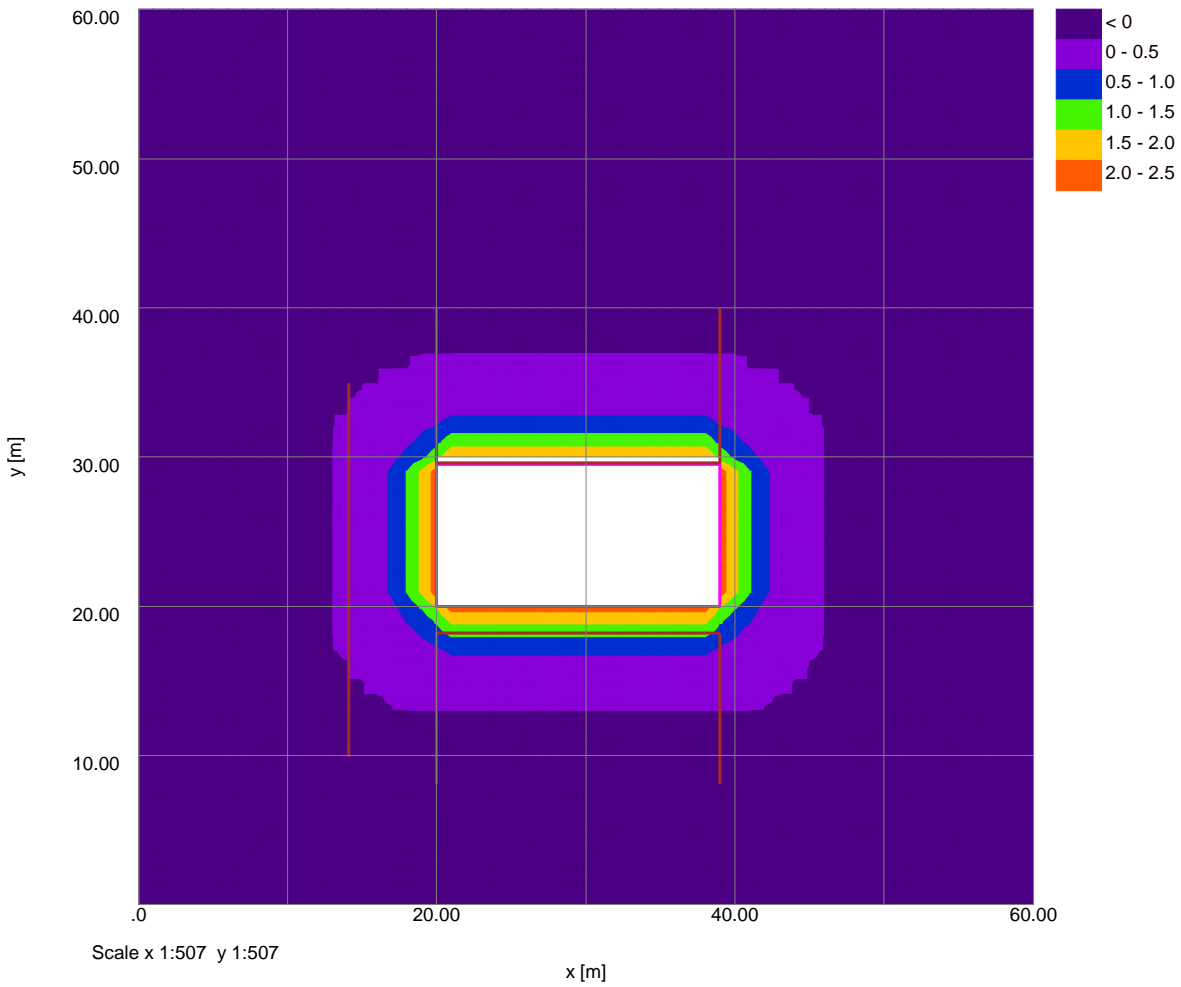
Displacement for No21A

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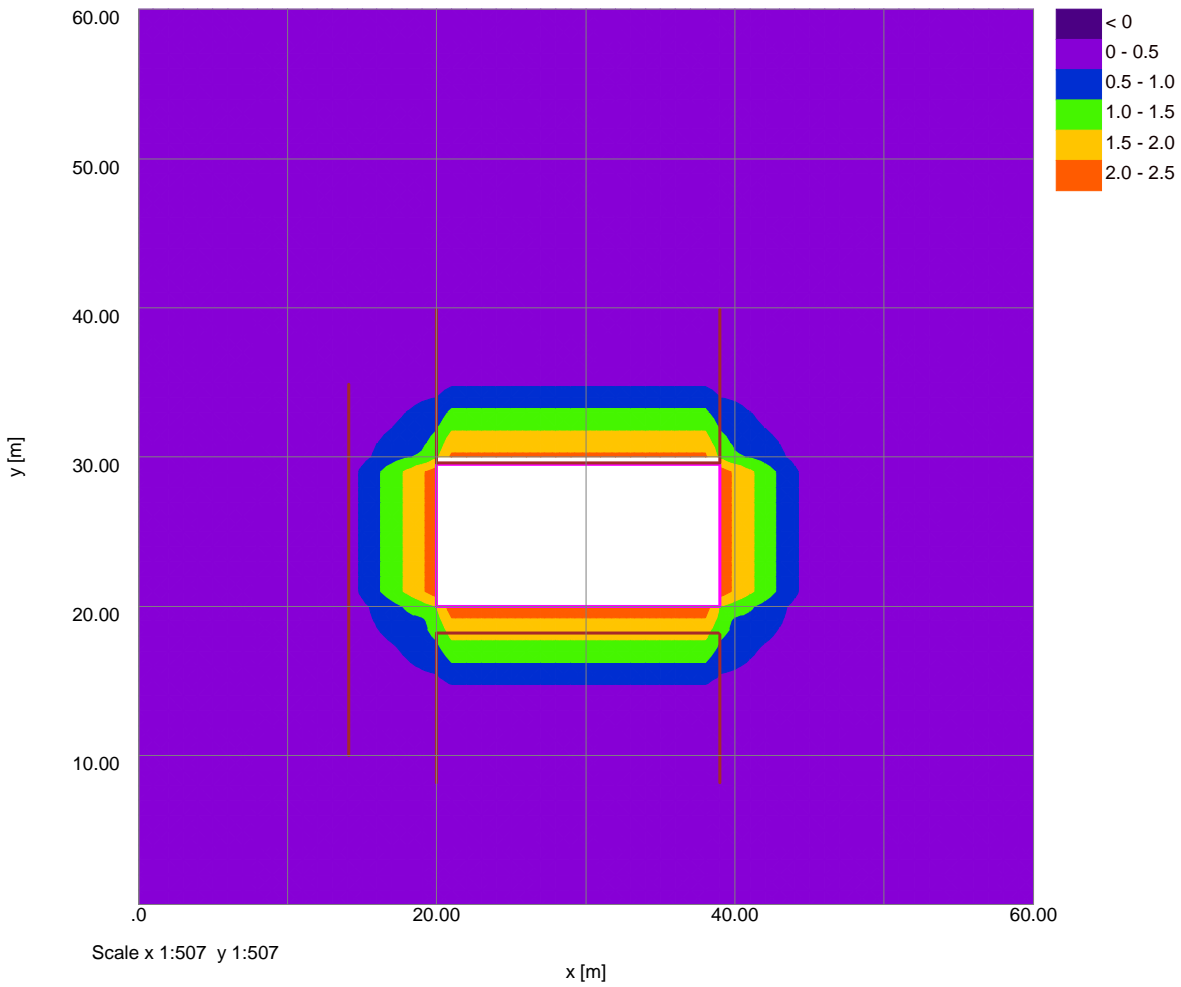
Distance from (20,40) in m



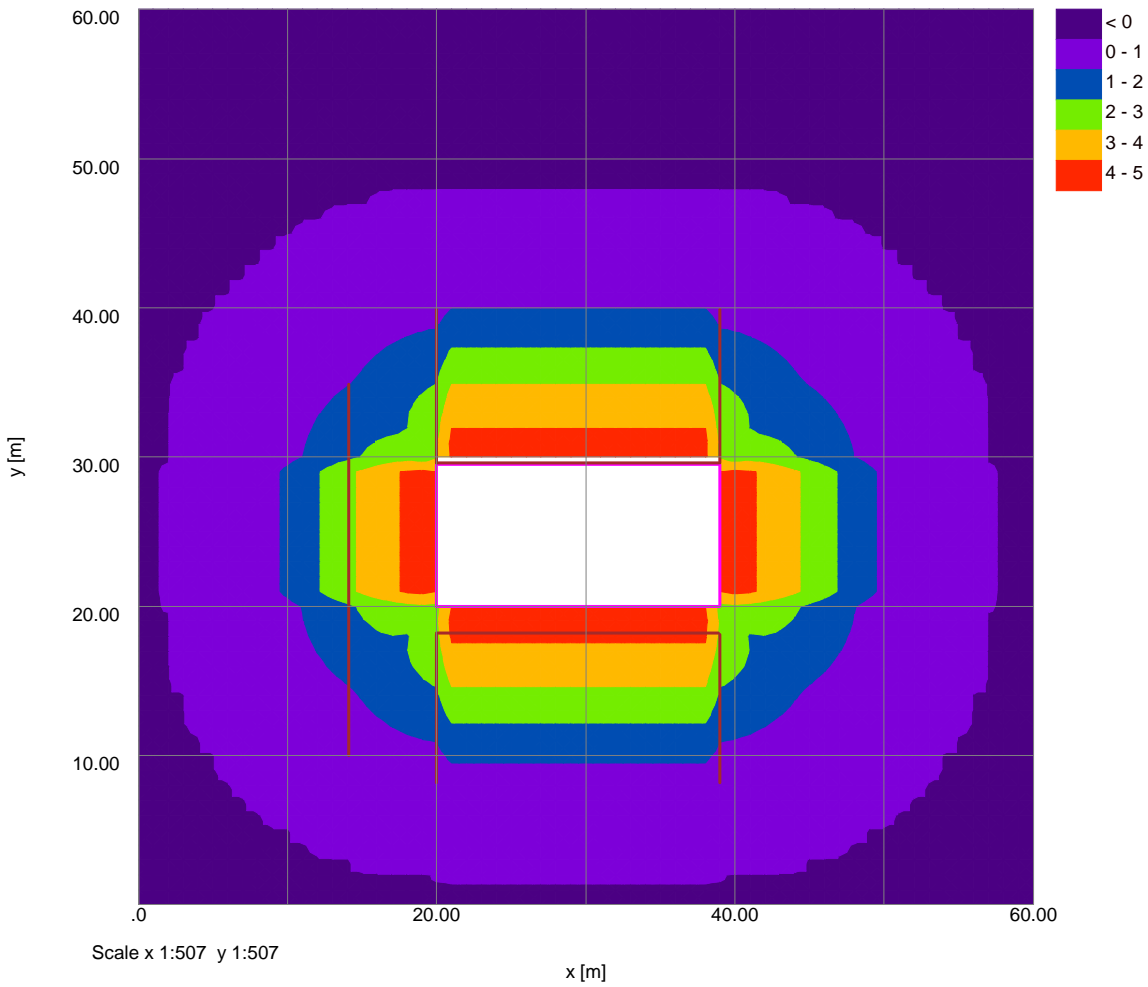
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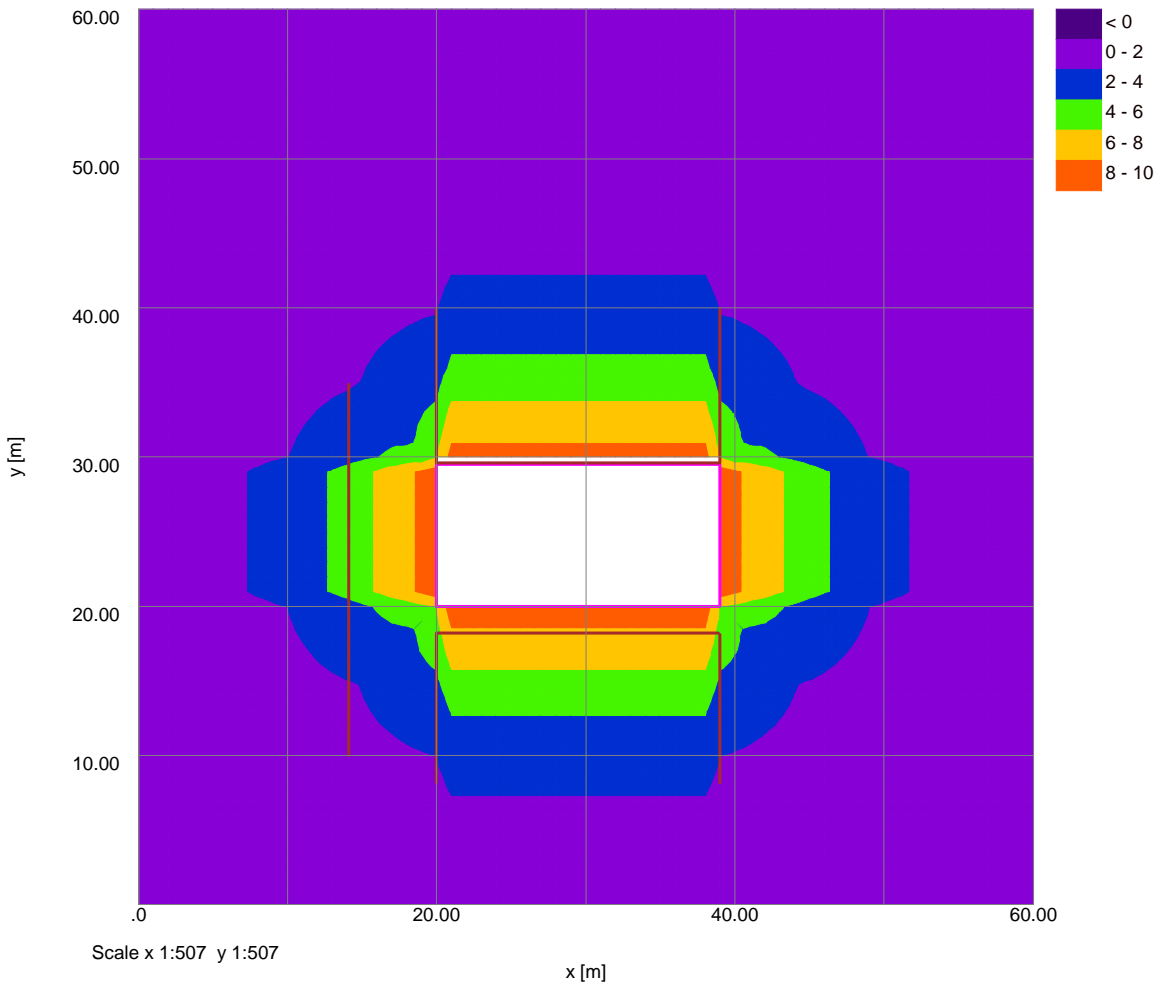
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Vertical Settlement Contours: Grid 1 (level 0.000m) (Interval 1mm)



Horizontal Displacement Contours: Grid 1 (level 0.000m) Interval 2mm





23 Downside Crescent
Wall Installation

Drg. Ref.

Made by Date Checked
07-Apr-2015

Specific Building Damage Results - Horizontal Displacements

Structure: No21 | Sub-structure: A

Dist.	Coordinates			Displacements			Along the Line	Perpendicular to Line
	x	y	z	x	y	z		
[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]
0.0	20.00000	29.60000	-0.85000	0.0	-7.4677	-7.4677	0.0	0.0 d
1.0400	20.00000	30.64000	-0.85000	0.0	-5.4890	-5.4890	0.0	0.0 d
2.0800	20.00000	31.68000	-0.85000	0.0	-4.9954	-4.9954	0.0	0.0 d
3.1200	20.00000	32.72000	-0.85000	0.0	-4.5018	-4.5018	0.0	0.0 d
4.1600	20.00000	33.76000	-0.85000	0.0	-4.0083	-4.0083	0.0	0.0 d
5.2000	20.00000	34.80000	-0.85000	0.0	-3.5147	-3.5147	0.0	0.0 d
6.2400	20.00000	35.84000	-0.85000	0.0	-3.0211	-3.0211	0.0	0.0 d
7.2800	20.00000	36.88000	-0.85000	0.0	-2.6683	-2.6683	0.0	0.0 d
8.3200	20.00000	37.92000	-0.85000	0.0	-2.4070	-2.4070	0.0	0.0 d
9.3600	20.00000	38.96000	-0.85000	0.0	-2.1457	-2.1457	0.0	0.0 d
10.4000	20.00000	40.00000	-0.85000	0.0	-1.8844	-1.8844	0.0	0.0 d

d - Displacements include imported displacements.

Structure: No21 | Sub-structure: B

Dist.	Coordinates			Displacements			Along the Line	Perpendicular to Line
	x	y	z	x	y	z		
[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]
0.0	20.00000	29.60000	-0.85000	0.0	-8.9292	0.0	-7.4677	d
1.0556	21.05556	29.60000	-0.85000	0.0	-8.9292	0.0	-8.9292	d
2.1111	22.11111	29.60000	-0.85000	0.0	-8.9292	0.0	-8.9292	d
3.1667	23.16667	29.60000	-0.85000	0.0	-8.9292	0.0	-8.9292	d
4.2222	24.22222	29.60000	-0.85000	0.0	-8.9292	0.0	-8.9292	d
5.2778	25.27778	29.60000	-0.85000	0.0	-8.9292	0.0	-8.9292	d
6.3333	26.33333	29.60000	-0.85000	0.0	-8.9292	0.0	-8.9292	d
7.3889	27.38889	29.60000	-0.85000	0.0	-8.9292	0.0	-8.9292	d
8.4444	28.44444	29.60000	-0.85000	0.0	-8.9292	0.0	-8.9292	d
9.5000	29.50000	29.60000	-0.85000	0.0	-8.9292	0.0	-8.9292	d
10.5556	30.55556	29.60000	-0.85000	0.0	-8.9292	0.0	-8.9292	d
11.6111	31.61111	29.60000	-0.85000	0.0	-8.9292	0.0	-8.9292	d
12.6667	32.66667	29.60000	-0.85000	0.0	-8.9292	0.0	-8.9292	d
13.7222	33.72222	29.60000	-0.85000	0.0	-8.9292	0.0	-8.9292	d
14.7778	34.77778	29.60000	-0.85000	0.0	-8.9292	0.0	-8.9292	d
15.8333	35.83333	29.60000	-0.85000	0.0	-8.9292	0.0	-8.9292	d
16.8889	36.88889	29.60000	-0.85000	0.0	-8.9292	0.0	-8.9292	d
17.9444	37.94444	29.60000	-0.85000	0.0	-8.9292	0.0	-8.9292	d
19.0000	39.00000	29.60000	-0.85000	0.0	-7.4677	0.0	-7.4677	d

d - Displacements include imported displacements.

Structure: No21 | Sub-structure: C

Dist.	Coordinates			Displacements			Along the Line	Perpendicular to Line
	x	y	z	x	y	z		
[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]
0.0	39.00000	29.60000	-0.85000	0.0	-7.4677	-7.4677	0.0	0.0 d
1.0400	39.00000	30.64000	-0.85000	0.0	-5.4890	-5.4890	0.0	0.0 d
2.0800	39.00000	31.68000	-0.85000	0.0	-4.9954	-4.9954	0.0	0.0 d
3.1200	39.00000	32.72000	-0.85000	0.0	-4.5018	-4.5018	0.0	0.0 d
4.1600	39.00000	33.76000	-0.85000	0.0	-4.0083	-4.0083	0.0	0.0 d
5.2000	39.00000	34.80000	-0.85000	0.0	-3.5147	-3.5147	0.0	0.0 d
6.2400	39.00000	35.84000	-0.85000	0.0	-3.0211	-3.0211	0.0	0.0 d
7.2800	39.00000	36.88000	-0.85000	0.0	-2.6683	-2.6683	0.0	0.0 d
8.3200	39.00000	37.92000	-0.85000	0.0	-2.4070	-2.4070	0.0	0.0 d
9.3600	39.00000	38.96000	-0.85000	0.0	-2.1457	-2.1457	0.0	0.0 d
10.4000	39.00000	40.00000	-0.85000	0.0	-1.8844	-1.8844	0.0	0.0 d

d - Displacements include imported displacements.

Structure: No25 | Sub-structure: A

Dist.	Coordinates			Displacements			Along the Line	Perpendicular to Line
	x	y	z	x	y	z		
[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]
0.0	20.00000	8.20000	-0.85000	0.0	1.5577	1.5577	0.0	0.0 d
1.0000	20.00000	9.20000	-0.85000	0.0	1.8090	1.8090	0.0	0.0 d
2.0000	20.00000	10.20000	-0.85000	0.0	2.0602	2.0602	0.0	0.0 d
3.0000	20.00000	11.20000	-0.85000	0.0	2.3115	2.3115	0.0	0.0 d
4.0000	20.00000	12.20000	-0.85000	0.0	2.5627	2.5627	0.0	0.0 d
5.0000	20.00000	13.20000	-0.85000	0.0	2.8140	2.8140	0.0	0.0 d
6.0000	20.00000	14.20000	-0.85000	0.0	3.2774	3.2774	0.0	0.0 d
7.0000	20.00000	15.20000	-0.85000	0.0	3.7520	3.7520	0.0	0.0 d
8.0000	20.00000	16.20000	-0.85000	0.0	4.2266	4.2266	0.0	0.0 d
9.0000	20.00000	17.20000	-0.85000	0.0	4.7012	4.7012	0.0	0.0 d
10.0000	20.00000	18.20000	-0.85000	0.0	6.2812	6.2812	0.0	0.0 d

d - Displacements include imported displacements.

Structure: No25 | Sub-structure: B

Dist.	Coordinates			Displacements			Along the Line	Perpendicular to Line
	x	y	z	x	y	z		
[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]
0.0	20.00000	18.20000	-0.85000	0.0	6.2812	0.0	6.2812	d
1.0556	21.05556	18.20000	-0.85000	0.0	7.7250	0.0	7.7250	d
2.1111	22.11111	18.20000	-0.85000	0.0	7.7250	0.0	7.7250	d
3.1667	23.16667	18.20000	-0.85000	0.0	7.7250	0.0	7.7250	d
4.2222	24.22222	18.20000	-0.85000	0.0	7.7250	0.0	7.7250	d
5.2778	25.27778	18.20000	-0.85000	0.0	7.7250	0.0	7.7250	d
6.3333	26.33333	18.20000	-0.85000	0.0	7.7250	0.0	7.7250	d
7.3889	27.38889	18.20000	-0.85000	0.0	7.7250	0.0	7.7250	d
8.4444	28.44444	18.20000	-0.85000	0.0	7.7250	0.0	7.7250	d
9.5000	29.50000	18.20000	-0.85000	0.0	7.7250	0.0	7.7250	d
10.5556	30.55556	18.20000	-0.85000	0.0	7.7250	0.0	7.7250	d
11.6111	31.61111	18.20000	-0.85000	0.0	7.7250	0.0	7.7250	d
12.6667	32.66667	18.20000	-0.85000	0.0	7.7250	0.0	7.7250	d
13.7222	33.72222	18.20000	-0.85000	0.0	7.7250	0.0	7.7250	d
14.7778	34.77778	18.20000	-0.85000	0.0	7.7250	0.0	7.7250	d
15.8333	35.83333	18.20000	-0.85000	0.0	7.7250	0.0	7.7250	d
16.8889	36.88889	18.20000	-0.85000	0.0	7.7250	0.0	7.7250	d
17.9444	37.94444	18.20000	-0.85000	0.0	7.7250	0.0	7.7250	d
19.0000	39.00000	18.20000	-0.85000	0.0	6.2812	0.0	6.2812	d

d - Displacements include imported displacements.

Structure: No25 | Sub-structure: C

Dist.	Coordinates			Displacements			Along the Line	Perpendicular to Line
	x	y	z	x	y	z		
[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]
0.0	39.00000	8.20000	-0.85000	0.0	1.5577	1.5577	0.0	0.0 d
1.0000	39.00000	9.20000	-0.85000	0.0	1.8090	1.8090	0.0	0.0 d
2.0000	39.00000	10.20000	-0.85000	0.0	2.0602	2.0602	0.0	0.0 d
3.0000	39.00000	11.20000	-0.85000	0.0	2.3115	2.3115	0.0	0.0 d
4.0000	39.00000	12.20000	-0.85000	0.0	2.5627	2.5627	0.0	0.0 d
5.0000	39.00000	13.20000	-0.85000	0.0	2.8140	2.8140	0.0	0.0 d
6.0000	39.00000	14.20000	-0.85000	0.0	3.2774	3.2774	0.0	0.0 d



GEA LIMITED
(GEOTECHNICAL & ENV ASSOC)

Job No.	Sheet No.	Rev.
CJ13331A		
Drg. Ref.		
Made by	Date	Checked
	07-Apr-2015	

23 Downside Crescent
Wall Installation

Dist.	Coordinates			Displacements		
	x	y	z	x	y	z
7.0000	39.00000	15.20000	-0.85000	0.0	3.7520	3.7520
8.0000	39.00000	16.20000	-0.85000	0.0	4.2266	4.2266
9.0000	39.00000	17.20000	-0.85000	0.0	4.7012	4.7012
10.0000	39.00000	18.20000	-0.85000	0.0	6.2812	6.2812

d - Displacements include imported displacements.

Structure: DSC | Sub-structure: a

Dist.	Coordinates			Displacements			
	x	y	z	x	y	z	Along the Line
[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]
0.0	14.10000	10.00000	0.00000	0.67526	1.1445	1.1445	-0.67526 d
1.0000	14.10000	11.00000	-0.01600	0.81017	1.2359	1.2359	-0.81017 d
2.0000	14.10000	12.00000	-0.03200	0.95518	1.2952	1.2952	-0.95518 d
3.0000	14.10000	13.00000	-0.04800	1.1082	1.3148	1.3148	-1.1082 d
4.0000	14.10000	14.00000	-0.06400	1.2647	1.2861	1.2861	-1.2647 d
5.0000	14.10000	15.00000	-0.08000	1.5209	1.2889	1.2889	-1.5209 d
6.0000	14.10000	16.00000	-0.09600	1.8258	1.2378	1.2378	-1.8258 d
7.0000	14.10000	17.00000	-0.11200	2.1837	1.1104	1.1104	-2.1837 d
8.0000	14.10000	18.00000	-0.12800	2.6034	0.88252	0.88252	-2.6034 d
9.0000	14.10000	19.00000	-0.14400	2.9746	0.50416	0.50416	-2.9746 d
10.0000	14.10000	20.00000	-0.16000	3.2300	0.0	0.0	-3.2300 d
11.0000	14.10000	21.00000	-0.17600	4.8208	0.0	0.0	-4.8208 d
12.0000	14.10000	22.00000	-0.19200	4.8208	0.0	0.0	-4.8208 d
13.0000	14.10000	23.00000	-0.20800	4.8208	0.0	0.0	-4.8208 d
14.0000	14.10000	24.00000	-0.22400	4.8208	0.0	0.0	-4.8208 d
15.0000	14.10000	25.00000	-0.24000	4.8208	0.0	0.0	-4.8208 d
16.0000	14.10000	26.00000	-0.25600	4.8208	0.0	0.0	-4.8208 d
17.0000	14.10000	27.00000	-0.27200	4.8208	0.0	0.0	-4.8208 d
18.0000	14.10000	28.00000	-0.28800	4.8208	0.0	0.0	-4.8208 d
19.0000	14.10000	29.00000	-0.30400	4.8208	0.0	0.0	-4.8208 d
20.0000	14.10000	30.00000	-0.32000	3.1208	-0.26447	-0.26447	-3.1208 d
21.0000	14.10000	31.00000	-0.33600	2.7992	-0.71166	-0.71166	-2.7992 d
22.0000	14.10000	32.00000	-0.35200	2.3957	-1.0151	-1.0151	-2.3957 d
23.0000	14.10000	33.00000	-0.36800	1.9908	-1.1810	-1.1810	-1.9908 d
24.0000	14.10000	34.00000	-0.38400	1.6687	-1.2727	-1.2727	-1.6687 d
25.0000	14.10000	35.00000	-0.40000	1.3831	-1.2894	-1.2894	-1.3831 d

d - Displacements include imported displacements.

Specific Building Damage Results - Vertical Displacements

Structure: No21 | Sub-structure: A

Dist.	Coordinates			Displacements
	x	y	z	
[m]	[m]	[m]	[m]	[mm]
Vertical Offset 1				
0.0	20.00000	29.60000	-0.85000	4.1711 d
1.0400	20.00000	30.64000	-0.85000	2.8178 d
2.0800	20.00000	31.68000	-0.85000	2.7285 d
3.1200	20.00000	32.72000	-0.85000	2.5318 d
4.1600	20.00000	33.76000	-0.85000	2.2889 d
5.2000	20.00000	34.80000	-0.85000	2.0296 d
6.2400	20.00000	35.84000	-0.85000	1.7532 d
7.2800	20.00000	36.88000	-0.85000	1.4630 d
8.3200	20.00000	37.92000	-0.85000	1.1783 d
9.3600	20.00000	38.96000	-0.85000	0.90559 d
10.4000	20.00000	40.00000	-0.85000	0.66162 d

d - Displacements include imported displacements.

Structure: No21 | Sub-structure: B

Dist.	Coordinates			Displacements
	x	y	z	
[m]	[m]	[m]	[m]	[mm]
Vertical Offset 1				
0.0	20.00000	29.60000	-0.85000	4.1711 d
1.0556	21.05556	29.60000	-0.85000	4.0418 d
2.1111	22.11111	29.60000	-0.85000	4.0418 d
3.1667	23.16667	29.60000	-0.85000	4.0418 d
4.2222	24.22222	29.60000	-0.85000	4.0418 d
5.2778	25.27778	29.60000	-0.85000	4.0418 d
6.3333	26.33333	29.60000	-0.85000	4.0418 d
7.3889	27.38889	29.60000	-0.85000	4.0418 d
8.4444	28.44444	29.60000	-0.85000	4.0418 d
9.5000	29.50000	29.60000	-0.85000	4.0418 d
10.556	30.55556	29.60000	-0.85000	4.0418 d
11.611	31.61111	29.60000	-0.85000	4.0418 d
12.667	32.66667	29.60000	-0.85000	4.0418 d
13.722	33.72222	29.60000	-0.85000	4.0418 d
14.778	34.77778	29.60000	-0.85000	4.0418 d
15.833	35.83333	29.60000	-0.85000	4.0418 d
16.889	36.88889	29.60000	-0.85000	4.0418 d
17.944	37.94444	29.60000	-0.85000	4.0418 d
19.000	39.00000	29.60000	-0.85000	4.1711 d

d - Displacements include imported displacements.

Structure: No21 | Sub-structure: C

Dist.	Coordinates			Displacements
	x	y	z	
[m]	[m]	[m]	[m]	[mm]
Vertical Offset 1				
0.0	39.00000	29.60000	-0.85000	4.1711 d
1.0400	39.00000	30.64000	-0.85000	2.8178 d
2.0800	39.00000	31.68000	-0.85000	2.7285 d
3.1200	39.00000	32.72000	-0.85000	2.5318 d
4.1600	39.00000	33.76000	-0.85000	2.2889 d
5.2000	39.00000	34.80000	-0.85000	2.0296 d
6.2400	39.00000	35.84000	-0.85000	1.7532 d
7.2800	39.00000	36.88000	-0.85000	1.4630 d
8.3200	39.00000	37.92000	-0.85000	1.1783 d
9.3600	39.00000	38.96000	-0.85000	0.90559 d
10.4000	39.00000	40.00000	-0.85000	0.66162 d

d - Displacements include imported displacements.

Structure: No25 | Sub-structure: A

Dist.	Coordinates			Displacements
	x	y	z	
[m]	[m]	[m]	[m]	[mm]
Vertical Offset 1				
0.0	20.00000	9.20000	-0.85000	0.41361 d
1.0000	20.00000	9.20000	-0.85000	0.59831 d
2.0000	20.00000	10.20000	-0.85000	0.82202 d
3.0000	20.00000	11.20000	-0.85000	1.0762 d
4.0000	20.00000	12.20000	-0.85000	1.3478 d
5.0000	20.00000	13.20000	-0.85000	1.6190 d
6.0000	20.00000	14.20000	-0.85000	1.9001 d
7.0000	20.00000	15.20000	-0.85000	2.1556 d
8.0000	20.00000	16.20000	-0.85000	2.3994 d
9.0000	20.00000	17.20000	-0.85000	2.6196 d
10.0000	20.00000	18.20000	-0.85000	3.5372 d

d - Displacements include imported displacements.

Structure: No25 | Sub-structure: B

Dist.	Coordinates	Displacements
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23 Downside Crescent
Wall Installation

[m] x [m] y [m] z [m] z [mm]

Vertical Offset 1

0.0	20.00000	18.20000	-0.85000	3.5372	d
1.0556	21.05556	18.20000	-0.85000	4.1459	d
2.1111	22.11111	18.20000	-0.85000	4.1459	d
3.1667	23.16667	18.20000	-0.85000	4.1459	d
4.2222	24.22222	18.20000	-0.85000	4.1459	d
5.2778	25.27778	18.20000	-0.85000	4.1459	d
6.3333	26.33333	18.20000	-0.85000	4.1459	d
7.3889	27.38889	18.20000	-0.85000	4.1459	d
8.4444	28.44444	18.20000	-0.85000	4.1459	d
9.5000	29.50000	18.20000	-0.85000	4.1459	d
10.556	30.55556	18.20000	-0.85000	4.1459	d
11.611	31.61111	18.20000	-0.85000	4.1459	d
12.667	32.66667	18.20000	-0.85000	4.1459	d
13.722	33.72222	18.20000	-0.85000	4.1459	d
14.778	34.77778	18.20000	-0.85000	4.1459	d
15.833	35.83333	18.20000	-0.85000	4.1459	d
16.889	36.88889	18.20000	-0.85000	4.1459	d
17.944	37.94444	18.20000	-0.85000	4.1459	d
19.000	39.00000	18.20000	-0.85000	3.5372	d

d - Displacements include imported displacements.

Structure: No25 | Sub-structure: C

Dist. Coordinates Displacements

[m] x [m] y [m] z [m] z [mm]

Vertical Offset 1

0.0	39.00000	8.20000	-0.85000	0.41361	d
1.0000	39.00000	9.20000	-0.85000	0.59831	d
2.0000	39.00000	10.20000	-0.85000	0.82202	d
3.0000	39.00000	11.20000	-0.85000	0.07632	d
4.0000	39.00000	12.20000	-0.85000	1.3478	d
5.0000	39.00000	13.20000	-0.85000	1.6190	d
6.0000	39.00000	14.20000	-0.85000	1.9001	d
7.0000	39.00000	15.20000	-0.85000	2.1556	d
8.0000	39.00000	16.20000	-0.85000	2.3994	d
9.0000	39.00000	17.20000	-0.85000	2.6196	d
10.000	39.00000	18.20000	-0.85000	3.5372	d

d - Displacements include imported displacements.

Structure: DSC | Sub-structure: a

Dist. Coordinates Displacements

[m] x [m] y [m] z [m] z [mm]

Vertical Offset 1

0.0	14.10000	10.00000	0.00000	0.36947	d
1.0000	14.10000	11.00000	-0.01600	0.49344	d
2.0000	14.10000	12.00000	-0.03200	0.62746	d
3.0000	14.10000	13.00000	-0.04800	0.76159	d
4.0000	14.10000	14.00000	-0.06400	0.88429	d
5.0000	14.10000	15.00000	-0.08000	1.0566	d
6.0000	14.10000	16.00000	-0.09600	1.2374	d
7.0000	14.10000	17.00000	-0.11200	1.4185	d
8.0000	14.10000	18.00000	-0.12800	1.5956	d
9.0000	14.10000	19.00000	-0.14400	1.7506	d
10.000	14.10000	20.00000	-0.16000	1.8736	d
11.000	14.10000	21.00000	-0.17600	2.7964	d
12.000	14.10000	22.00000	-0.19200	2.7964	d
13.000	14.10000	23.00000	-0.20800	2.7964	d
14.000	14.10000	24.00000	-0.22400	2.7964	d
15.000	14.10000	25.00000	-0.24000	2.7964	d
16.000	14.10000	26.00000	-0.25600	2.7964	d
17.000	14.10000	27.00000	-0.27200	2.7964	d
18.000	14.10000	28.00000	-0.28800	2.7964	d
19.000	14.10000	29.00000	-0.30400	2.7964	d
20.000	14.10000	30.00000	-0.32000	1.8169	d
21.000	14.10000	31.00000	-0.33600	1.6764	d
22.000	14.10000	32.00000	-0.35200	1.5094	d
23.000	14.10000	33.00000	-0.36800	1.3266	d
24.000	14.10000	34.00000	-0.38400	1.1471	d
25.000	14.10000	35.00000	-0.40000	0.96656	d

d - Displacements include imported displacements.

Specific Building Damage Results - All Segments

Structure: No21 | Sub-structure: A

Vertical Offset from Line for Vertical Movement	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature	Damage Category
Calculations		[m]	[m]		[%]	[%]	[%]			[m]	
0	1	0.0	2.9352	Hogging	0.026610	0.098057	0.10375	-0.0018990	0.0012987	675.22	2 (Slight)
	2	2.9352	4.1468	Sagging	856.96E-6	0.044711	0.045212	-474.36E-6	278.95E-6	20299.	(Negligible) 0
	3	7.0820	3.2180	Hogging	709.61E-6	0.025667	0.025833	-339.18E-6	278.95E-6	31404.	(Negligible) 0

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.

Structure: No21 | Sub-structure: B

Vertical Offset from Line for Vertical Movement	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature	Damage Category
Calculations		[m]	[m]		[%]	[%]	[%]			[m]	
0	1	0.0	3.1667	Hogging	0.0027226	0.0	0.0027068	0.0	122.52E-6	6892.6	(Negligible) 0
	2	3.1667	12.667	None	0.0	0.0	0.0	0.0	0.0	-	(Negligible) 0
	3	15.833	3.0667	Hogging	0.0026221	0.0	0.0026079	0.0	-122.52E-6	6632.0	(Negligible) 0

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.

Structure: No21 | Sub-structure: C

Vertical Offset from Line for Vertical Movement	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature	Damage Category
Calculations		[m]	[m]		[%]	[%]	[%]			[m]	
0	1	0.0	2.9352	Hogging	0.026610	0.098057	0.10375	-0.0018990	0.0012987	675.22	2 (Slight)
	2	2.9352	4.1468	Sagging	856.96E-6	0.044711	0.045212	-474.36E-6	278.95E-6	20299.	(Negligible) 0
	3	7.0820	3.2180	Hogging	709.61E-6	0.025667	0.025833	-339.18E-6	278.95E-6	31404.	(Negligible) 0

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.

Structure: No25 | Sub-structure: A

Vertical Offset from Line for Vertical Movement	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature	Damage Category
Calculations		[m]	[m]		[%]	[%]	[%]			[m]	
0	1	0.0	2.9352	Hogging	0.026610	0.098057	0.10375	-0.0018990	0.0012987	675.22	2 (Slight)
	2	2.9352	4.1468	Sagging	856.96E-6	0.044711	0.045212	-474.36E-6	278.95E-6	20299.	(Negligible) 0
	3	7.0820	3.2180	Hogging	709.61E-6	0.025667	0.025833	-339.18E-6	278.95E-6	31404.	(Negligible) 0

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.



23 Downside Crescent
Wall Installation

Vertical Movement Calculations	Strain	Strain	Horizontal Displacement Curve	Vertical Displacement Curve	Curvature
[m] 0	[%] 0.0014806	[%] 0.025125	[m] -251.19E-6	[m] -271.52E-6	[m] 24329.0
1 0.0 4.8107 Hogging					(Negligible) 0
2 4.8107 2.2868 Sagging	619.33E-6	0.045121 0.045326	-474.36E-6	-281.01E-6	55298.0
3 7.0975 2.8025 Hogging	0.014896	0.082960 0.086005	-0.0015776	-916.20E-6	1097.5 2 (Slight)

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.

Structure: No25 | Sub-structure: B

Vertical Offset from Line for Vertical Movement Calculations	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature	Damage Category
[m] 0		[m] 0.0	[m] 3.1667	Hogging	[%] 0.012815	[%] 0.0	[%] 0.012523	0.0	-576.66E-6	[m] 1464.4	0 (Negligible)
	2	3.1667	12.667	None	0.0	0.0	0.0	0.0	0.0	-	0 (Negligible)
	3	15.833	3.0667	Sagging	0.012342	0.0	0.012078	0.0	576.66E-6	1409.0	0 (Negligible)

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.

Structure: No25 | Sub-structure: C

Vertical Offset from Line for Vertical Movement Calculations	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature	Damage Category
[m] 0		[m] 0.0	[m] 4.8107	Hogging	[%] 0.0014806	[%] 0.025125	[%] 0.025640	-251.19E-6	-271.52E-6	[m] 24329.0	0 (Negligible)
	2	4.8107	2.2868	Sagging	619.33E-6	0.045121	0.045326	-474.36E-6	-281.01E-6	55298.0	0 (Negligible)
	3	7.0975	2.8025	Hogging	0.014896	0.082960	0.086005	-0.0015776	-916.20E-6	1097.5 2 (Slight)	0 (Negligible)

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.

Structure: DSC | Sub-structure: a

Vertical Offset from Line for Vertical Movement Calculations	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature	Damage Category
[m] 0		[m] 0.0	[m] 1.9640	Hogging	[%] 250.79E-6	[%] 0.0075619	[%] 0.0079429	-91.341E-6	-134.04E-6	[m] 79217.0	0 (Negligible)
	2	1.9640	0.076596	Hogging	2.1087E-6	0.0038276	0.0038279	-59.299E-6	-134.13E-6	3.5573E+6	0 (Negligible)
	3	2.0406	4.1071	Hogging	0.0012046	-0.0018741	397.36E-6	127.47E-6	-181.12E-6	41832.0	0 (Negligible)
	4	6.1477	1.9534	Sagging	147.01E-6	-0.019182	0.0038365	378.50E-6	-181.12E-6	50408.0	0 (Negligible)
	5	8.1010	2.2806	Hogging	0.010873	-0.037020	0.0078875	504.42E-6	-922.81E-6	5607.2	0 (Negligible)
	6	10.382	2.6184	Sagging	0.016510	0.0	0.016561	0.0	-922.81E-6	3832.9	0 (Negligible)
	7	13.000	4.0000	None	0.0	0.0	0.0	0.0	0.0	-	0 (Negligible)
	8	17.000	2.6248	Sagging	0.017664	-0.0062954	0.011391	264.54E-6	979.73E-6	3576.1	0 (Negligible)
	9	19.625	2.3088	Hogging	0.011185	-0.035939	0.0076995	447.39E-6	979.73E-6	5194.0	0 (Negligible)
	10	21.934	2.9664	Hogging	41.768E-6	-0.0098671	0.0019734	303.58E-6	182.84E-6	74429.0	0 (Negligible)

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.

Specific Building Damage Results - Critical Values for All Segments within Each Sub-Structure

Structure: No21 | Sub-structure: A

Vertical Offset from Line for Vertical Movement Calculations	Deflection Ratio	Average Horizontal Strain	Maximum Slope	Maximum Settlement	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature (Hogging)	Min. Radius of Curvature (Sagging)	Damage Category
[m] 0	[%] 0.0226610	[%] 0.098057	[mm] 0.0012987	[mm] 4.1711	[%] 0.10375	[%] -0.0018990	[%] 0.0012987	[m] 675.22	[m] 20299.2	2 (Slight)

Structure: No21 | Sub-structure: B

Vertical Offset from Line for Vertical Movement Calculations	Deflection Ratio	Average Horizontal Strain	Maximum Slope	Maximum Settlement	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature (Hogging)	Min. Radius of Curvature (Sagging)	Damage Category
[m] 0	[%] 0.0027226	[%] 0.0	[mm] -122.52E-6	[mm] 4.1711	[%] 0.0027068	[%] 0.0	[%] -122.52E-6	[m] 6632.0	[m] -	0 (Negligible)

Structure: No21 | Sub-structure: C

Vertical Offset from Line for Vertical Movement Calculations	Deflection Ratio	Average Horizontal Strain	Maximum Slope	Maximum Settlement	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature (Hogging)	Min. Radius of Curvature (Sagging)	Damage Category
[m] 0	[%] 0.0226610	[%] 0.098057	[mm] 0.0012987	[mm] 4.1711	[%] 0.10375	[%] -0.0018990	[%] 0.0012987	[m] 675.22	[m] 20299.2	2 (Slight)

Structure: No25 | Sub-structure: A

Vertical Offset from Line for Vertical Movement Calculations	Deflection Ratio	Average Horizontal Strain	Maximum Slope	Maximum Settlement	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature (Hogging)	Min. Radius of Curvature (Sagging)	Damage Category
[m] 0	[%] 0.014896	[%] 0.082960	[mm] -916.20E-6	[mm] 3.4454	[%] 0.086005	[%] -0.0015776	[%] -916.20E-6	[m] 1097.5	[m] 55298.2	2 (Slight)

Structure: No25 | Sub-structure: B

Vertical Offset from Line for Vertical Movement Calculations	Deflection Ratio	Average Horizontal Strain	Maximum Slope	Maximum Settlement	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature (Hogging)	Min. Radius of Curvature (Sagging)	Damage Category
[m] 0	[%] 0.012815	[%] 0.0	[mm] -576.66E-6	[mm] 4.1459	[%] 0.012523	[%] 0.0	[%] -576.66E-6	[m] -	[m] 1409.0	0 (Negligible)



Vertical Offset from Line for Vertical	Deflection Ratio	Average Horizontal Strain	Maximum Slope	Maximum Settlement	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement	Maximum Gradient of Vertical Displacement	Min. Radius of Curvature (Hogging)	Min. Radius of Curvature (Sagging)	Damage Category
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Structure: No25 | Sub-structure: C

Vertical Offset from Line for Vertical Movement Calculations	Deflection Ratio	Average Horizontal Strain	Maximum Slope	Maximum Settlement	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement	Maximum Gradient of Vertical Displacement	Min. Radius of Curvature (Hogging)	Min. Radius of Curvature (Sagging)	Damage Category
[m] 0	[%] 0.014896	[%] 0.082960	-916.20E-6	[mm] 3.4454	[%] 0.086005	-0.0015776	-916.20E-6	[m] 1097.5	[m] 55298.2	2 (Slight)

Structure: DSC | Sub-structure: a

Vertical Offset from Line for Vertical Movement Calculations	Deflection Ratio	Average Horizontal Strain	Maximum Slope	Maximum Settlement	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement	Maximum Gradient of Vertical Displacement	Min. Radius of Curvature (Hogging)	Min. Radius of Curvature (Sagging)	Damage Category
[m] 0	[%] 0.017664	[%] -0.037020	979.73E-6	[mm] 2.7964	[%] 0.016561	504.42E-6	979.73E-6	[m] 5194.0	[m] 3576.1	0 (Negligible)

Specific Building Damage Results - Critical Segments within Each Structure

Structure Name	Parameter	Critical Sub-Structure	Critical Segment	Start	End	Curvature	Maximum Slope	Maximum Settlement	Max. Tensile Strain	Min. Radius of Curvature (Hogging)	Min. Radius of Curvature (Sagging)	Damage Category
No21	Maximum Slope	A		[m]	[m]	2.9352 Hogging	0.0012987		4.1711	0.10375	675.22	- 2 (Slight)
	Maximum Settlement	A		1	0.0	2.9352 Hogging	0.0012987		4.1711	0.10375	675.22	- 2 (Slight)
	Max. Tensile Strain	A		1	0.0	2.9352 Hogging	0.0012987		4.1711	0.10375	675.22	- 2 (Slight)
	Min. Radius of Curvature (Hogging)	A		1	0.0	2.9352 Hogging	0.0012987		4.1711	0.10375	675.22	- 2 (Slight)
No25	Maximum Slope	A		3	7.0975	9.9000 Hogging	916.20E-6		3.4454	0.086005	1097.5	- 2 (Slight)
	Maximum Settlement	B		1	0.0	3.1667 Sagging	576.66E-6		4.1459	0.012523	-	1464.4 0 (Negligible)
	Max. Tensile Strain	A		3	7.0975	9.9000 Hogging	916.20E-6		3.4454	0.086005	1097.5	- 2 (Slight)
	Min. Radius of Curvature (Hogging)	A		3	7.0975	9.9000 Hogging	916.20E-6		3.4454	0.086005	1097.5	- 2 (Slight)
DSC	Maximum Slope	a		8	17.000	19.625 Sagging	979.73E-6		2.7964	0.011391	-	3576.1 0 (Negligible)
	Maximum Settlement	a		6	10.382	13.000 Sagging	922.81E-6		2.7964	0.016561	-	3832.9 0 (Negligible)
	Max. Tensile Strain	a		6	10.382	13.000 Sagging	922.81E-6		2.7964	0.016561	-	3832.9 0 (Negligible)
	Min. Radius of Curvature (Hogging)	a		9	19.625	21.934 Hogging	979.73E-6		2.1844	0.0076995	5194.0	- 0 (Negligible)
DSC	Min. Radius of Curvature (Sagging)	a		8	17.000	19.625 Sagging	979.73E-6		2.7964	0.011391	-	3576.1 0 (Negligible)

Specific Building Damage Results - All Combined Segments

Structure: No21 | Sub-structure: A

Vertical Offset from Line for Vertical Movement Calculations	Combined Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Damage Category
[m]	[m]	[m]			[%]	[%]	[%]	
No structures have segments combined.								

Structure: No21 | Sub-structure: B

Vertical Offset from Line for Vertical Movement Calculations	Combined Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Damage Category
[m]	[m]	[m]			[%]	[%]	[%]	
No structures have segments combined.								

Structure: No21 | Sub-structure: C

Vertical Offset from Line for Vertical Movement Calculations	Combined Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Damage Category
[m]	[m]	[m]			[%]	[%]	[%]	
No structures have segments combined.								

Structure: No25 | Sub-structure: A

Vertical Offset from Line for Vertical Movement Calculations	Combined Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Damage Category
[m]	[m]	[m]			[%]	[%]	[%]	
No structures have segments combined.								

Structure: No25 | Sub-structure: B

Vertical Offset from Line for Vertical Movement Calculations	Combined Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Damage Category
[m]	[m]	[m]			[%]	[%]	[%]	
No structures have segments combined.								

Structure: No25 | Sub-structure: C

Vertical Offset from Line for Vertical Movement Calculations	Combined Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Damage Category
[m]	[m]	[m]			[%]	[%]	[%]	
No structures have segments combined.								



Job No.	Sheet No.	Rev.
J13331A		
Drg. Ref.		
Made by	Date	Checked
	07-Apr-2015	

Vertical
 Movement
 Calculations
 [m] [m] [m] [%] [%] [%]
 No structures have segments combined.

Structure: DSC | Sub-structure: a

Vertical Offset from Line for Vertical Movement Calculations	Combined Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Damage Category
[m]	[m]	[m]			[%]	[%]	[%]	

No structures have segments combined.

Geotechnical & Environmental Associates (GEA) is an engineer-led and client-focused independent specialist providing a complete range of geotechnical and contaminated land investigation, analytical and consultancy services to the property and construction industries.

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